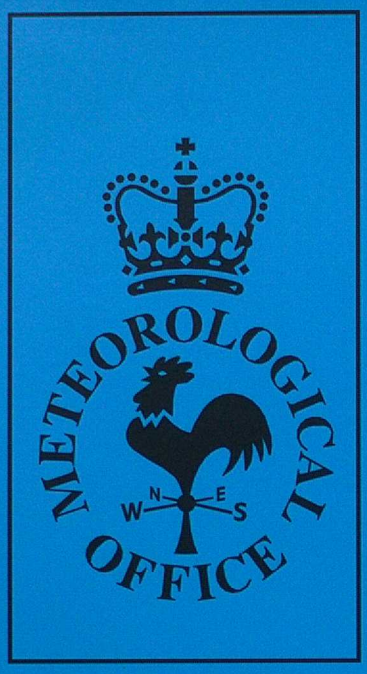

Forecasting Research

Forecasting Research Division
Technical Report No. 191

PARALLEL TRIAL OF T+120 MINUTE AND T+150 MINUTE DATA CUTOFFS IN THE GLOBAL MODEL

by

S J Lorrimer, O M Hammon and C A Wilson

May 1996

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ABSTRACT

This technical report contains the results of subjective and objective assessments of a test of advancing the data cutoff time for the global forecast model from 185 minutes to 150 or 120 minutes. It builds on previous work by Wilson, Hammon and Leighton (1996, NWP Technical Report 190) who found that a cutoff of 90 minutes was unacceptable.

Both the T+120 and T+150 minute cutoffs degrade the operational forecast, although by less than the T+90 minute cutoff. The jet level winds at short periods are the most seriously degraded, especially in the T+120 minute trial. The verification against analyses is apparently improved in the tropics due to the verifying analyses being smoother, rather than any genuine improvement in forecast quality. Both trials deteriorated the composite NWP index by 0.7. There was a large increase in analysis error of tropical cyclones , reflecting the lack of data in the earlier cut-off.

PARALLEL TRIAL OF T+120 MINUTE AND T+150 MINUTE DATA CUTOFFS IN THE GLOBAL MODEL

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1. INTRODUCTION

This technical report contains the results of subjective and objective assessments of a test of advancing the data cutoff time for the global forecast model from 185 minutes to 150 or 120 minutes. It builds on previous work by Wilson, Hammon and Leighton (1996, WHL96 hereafter) who found that a cutoff of 90 minutes was unacceptable. During the WHL96 trial (August-September 1995) the operational data cutoff was at 200 minutes.

A need for earlier availability of forecasts has been highlighted by a review of the user requirement for NWP. Aviation customers would like global model wind and temperature forecasts to be available sooner. Also, the detailed guidance of the mesoscale model needs to be available to CFO as early as possible. However, the timeliness of the model products must be weighed against its quality. The use of earlier cutoff times is one possible method for improving the timeliness of forecasts.

The parallel trial was run from 21st February 1996-31st March 1996. The trial cutoff was changed from 120 minutes to 150 minutes on 8th March 1996, so we have tested each data cutoff in a trial of approximately three weeks. No attempt has been made to assess the impact of reducing the cutoff time on our ability to forecast extreme events. It is unlikely that a sample period of three weeks would contain such events; specific case study tests would be more appropriate. It remains an area of outstanding concern that shortening the cutoff time may deteriorate our ability to forecast extreme events effectively.

2. DATA RECEIPT

The time of receipt of the total data used in the operational assimilation at 12Z and 00Z during the period 19/02/96 and 27/03/96 has been analysed in Tables 2.1 and 2.2 respectively in Appendix A. For comparison with WHL96 we have included all the data up to a cutoff of 200 minutes, but it should be remembered that the operational cutoff is now 185 minutes. These

tables indicate that 72% of data (available at T+200 minutes) were received overall by T+90 minutes, increasing to 80% by T+120 minutes and to 90% by T+150 minutes. There were a few differences between the data received at 12Z and 00Z, e.g. increased AMDARS and fewer AIREPS at 00Z.

In Figure 2.1, the top diagram illustrates the distribution of 12Z synops received after T+150 minutes during the period 19/02/96 to 31/03/96. The middle diagram shows the number of observations received at various times between T+90 minutes and T+200 minutes for the Northern Hemisphere, Tropics and Southern Hemisphere. The bottom diagram gives the total number of synops received between T+90 and T+200 minutes. Similarly, the same information is given in Figures 2.2 - 2.9 respectively for ships, sondes, AMDARS, AIREPS, drifting buoys, SATOBS, SATEMS and moored buoys.

2.1 Northern Hemisphere (north of 30N) data

The most significant data in the Northern Hemisphere that was missed by the early cut-offs at T+120/T+150 minutes were AMDARS and AIREPS. Both are asynoptic which means that some will be lost whatever cut-off time is chosen. Tables 2.1 and 2.2 in Appendix A show that for AMDARS only 72% of reports used in the operational assimilation (with a data cutoff of T+200 minutes) were received by T+120 minutes, increasing to > 80% by T+150 minutes. The top diagrams in Figures 2.4 a/b show that the majority of the late AMDARS were from North America and the North Atlantic. The middle diagram in Figure 2.4 shows the number of AMDARS received after T+90 minutes, indicating peaks of > 2000 reports between T+155 and T+175 minutes. The corresponding figures for 00Z AMDARS are similar, but the total number of reports was significantly larger (by ~30%).

Similarly, the importance of AIREPS to the Northern Hemisphere is shown by the top diagrams in Figures 2.5 a/b, which indicate that the majority of late AIREP reports were from the North Atlantic and North Pacific. Tables 2.1 and 2.2 in Appendix A show that for AIREPS only 66-72% of reports used in the operational assimilation were received by T+120 minutes, increasing to > 80% by T+150 minutes. The middle diagram in Figure 2.5a shows a number of peaks of 1000-1500 AIREPS between T+125 and T+185 minutes for the Northern Hemisphere. The corresponding figures for 00Z AIREPS are similar, but the total number of AIREPS was smaller.

The late receipt of synops, sondes and ships were of less importance in the Northern Hemisphere than late aircraft reports. For synops, Tables 2.1 and 2.2 in Appendix A indicate that >90% of synops used in the operational assimilation were received by T+120 minutes. Some important North American synops were missing at T+120 and T+150 only on one or two isolated occasions. Similarly for ships, >90%of observations were available by T+120 minutes, although the middle diagram in Figure 2.2 shows a small peak of observations at T+120 minutes which would only just have made the early cut-off. For sondes, Tables 2.1 and 2.2 in Appendix A indicate that only 62% of total sondes were received by T+120, increasing to >80% by T+150 minutes. In the Northern Hemisphere most of the late sondes were from Eastern Europe and Asia. The important North American sondes were received after T+120 minutes on only one or

two occasions and all were received by T+150 minutes.

For SATOBS, the main data received after T+120/T+150 minutes was from the Indian satellite, but the top diagram in Figure 2.7 also shows a possible impact in the North Pacific. For SATEMS, 79-80% of data were received by T+120 minutes, increasing to 86-87% by T+150 minutes. SATEMS were received fairly continuously up to T+200 minutes and the top diagrams in Figures 2.8 a/b indicate that late SATEMS missing the early cut-offs could have an impact in the Northern Hemisphere.

Drifting buoys are asynoptic so a significant number of observations are likely to be missed by an early cut-off time. The top diagram in Figure 2.6 indicates that reports from drifting buoys were received later than T+150 minutes from the North Atlantic and North Pacific.

2.2 Tropics (30N - 30S) data

Satellite observations were of more importance in the Tropics during the period of the trial. The top diagram in Figure 2.7 indicates that a large number of SATOBS were received after T+150 from the Indian satellite, with the middle diagram indicating a major peak in SATOBS between T+140 and T+155 minutes. If these SATOBS are used in the operational assimilation, then there could be a large impact on the analysis in the Indian and Central Pacific Oceans from using an earlier cut-off time at T+120 and T+150 minutes. Similarly, the top diagrams in Figures 2.8 a/b indicate that a large number of SATEMS were received after T+150 minutes in the Tropics, with reports received fairly continuously up to T+200 minutes.

Aircraft reports were of less importance in the Tropics during the trial although the middle diagram in Figure 2.4b indicates a peak of 3000 AMDARS received at 0300Z, mainly from Africa.

The top diagram in Figure 2.1 indicates that several important synops, notably from South America, India and Malaysia were often received after T+150 minutes. The middle diagram shows a peak time for late synops at T+135 minutes with a smaller peak at T+165 minutes. Figure 2.3 indicates a similar situation for tropical sondes with a peak at T+135 minutes for the receipt of late sondes.

2.3 Southern Hemisphere (S of 30S) data

In the Southern Hemisphere, the most important data omitted by the early cut-off times included late synops, AMDARS, drifting buoys and SATEMS. The central diagram, Figure 2.1a, indicates that a large number (~2700) of Southern Hemisphere synops were received between T+135 and T+140 minutes, with a smaller peak period (~1500 synops) between T+165 and T+175 minutes. In contrast, the central diagram in Figure 2.3 shows that most Southern Hemisphere sondes were received by T+120 minutes.

For AMDARS, the central diagrams in Figures 2.4 a/b show peak times at T+180 minutes, i.e. at 1500Z and 0300Z, for the receipt of late AMDARS, mainly over Australia. Drifting buoys are especially important in the Southern Hemisphere due to the large areas of Oceans and the central diagram in Figure 2.6 indicates peak times at T+130,165 and 190 minutes for the receipt

of late observations. SATEMS were received at regular intervals and those omitted from the early cut-off analyses seemed to have an important impact upon the forecasts in the Southern Hemisphere.

3. Objective Verification

Global verification was available from 21st February 1996 to 11th March 1996 with a 120 minute cutoff and from 8th March 1996 to 31st March 1996 with a 150 minute cutoff. Besides standard verification, we included an intermediate run, starting at 06Z, in the trial as a 'no-obs' run. This estimates the worst possible degradation due to an early cutoff. However, the verification of this run is very incomplete; these results are extremely noisy due to the limited sample. We will also discuss here a comparison of the trial with the LAM verification. However, as we will discuss, this has several drawbacks from inconsistencies in the methods of verification.

The verification has been divided into four areas: area 2, northern hemisphere to 20N, Tropics between 20N and 20S and southern hemisphere from 20S. We found the bias and RMS for each field. For verification against analyses the anomaly correlation was also found. However, even by T+120 this had shown very little impact and so we will not discuss it here, except to note that what little impact is apparent shows broad agreement with the results discussed here.

Inevitably, verification was not available for the entire period. In Table 3.1 we show those dates for which we could obtain verification. The double line shows the border between runs with a 120 minute cutoff and a 150 minute cutoff.

TABLE 3.1

Those dates for which verification against analysis was available. The double line shows the border between the T+120 minute and T+150 minute trial. In addition, verification against observations was not available between 960320 and 960325 inclusive.

	21	22	23	24	25	26	27	28	29	1	2	3	4	5	6	7	8	9
T+00	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✔	✔
T+24		✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✔	✘	✔
T+48			✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✔	✔	✘
T+72				✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✔	✔	✔
T+96					✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✔	✔	✔
T+120						✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✔	✔	✔

	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25
T+00	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✔	✔	✘	✔
T+24	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✔	✔	✘	✔
T+48	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✘	✔	✘	✔
T+72	✘	✔	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✘	✘	✘	✔
T+96	✔	✘	✔	✔	✔	✔	✔	✔	✔	✔	✘	✘	✔	✔	✘	✘
T+120	✔	✔	✘	✔	✔	✔	✔	✔	✔	✔	✘	✘	✔	✔	✘	✘

	26	27	28	29	30	31
T+00	✔	✔	✔	✔	✔	✔
T+24	✔	✔	✔	✔	✔	✔
T+48	✔	✔	✔	✔	✔	✔
T+72	✔	✔	✔	✔	✔	✔
T+96	✔	✔	✔	✔	✔	✔
T+120	✘	✔	✔	✔	✔	✔

3.1 One Hundred and Twenty Minute Data Cutoff

3.1.1 Short Period Forecasts

The most critical parts of these trials are the short period forecasts. It is in this period that we expect the maximum impact; they are also critical for aviation forecasting and providing boundary conditions for LAM forecasts. Similarly to Wilson, Hammon & Leighton (1996) we verified a 'no-obs' forecast from 06Z. The 06Z run then estimates the maximum possible detriment due to an early data cutoff. The position of a forecaster is worse than this, since if the operational forecast is unavailable they are forced to use a forecast that is 12 hours older, not six, since forecasts are at present only made from 00Z and 12Z. The verification of the 06Z runs was patchy and so the verification scores are noisy. However, they contrast well with WHL96, who found that using a T+90 minute cutoff deteriorated the forecast by a significant fraction of the deterioration that would be generated by using the 06Z run. With a data cutoff at T+120 minutes the two 12Z runs (trial and operational) are much closer together than either is to the 06Z run.

Winds

WHL96 found that, when verified against radio sondes, a T+90 minute run produced a deterioration in the RMS VWE's of 3-4%; they found a deterioration of 5-14% for the 06Z run. In Figure 3.1 we show the percentage deterioration in RMS VWE's at T+12 for the trial (solid line) and in comparison with the T+18 forecast from the 06Z run (dotted line). The vertical dotted lines are at ±1%, which is generally taken to be the level of practical significance. As relatively few 06Z run forecasts were verified, the noise level is probably a few times this. Figure 3.1 shows that the change in the trial RMS VWE's is a small deterioration (mainly <1%), except in the tropics where the deterioration reaches 6%. WHL96 also found that the deterioration was worst in the tropics. Using the 06Z run leads to a deterioration of a similar size to that found by WHL96. At T+24 (Figure 3.2) the deteriorations are up to 4%. When verifying against Air Reps or AMDARS (Figures 3.3-3.6) the picture is similar, although the AIREPS in particular are noisier and the deterioration is somewhat larger (6-8%) with the largest degradations in the tropics. Both this study and WHL96 find that jet levels are the worst affected.

Temperatures

Figures 3.7 and 3.8 show similar results to Figures 3.1 and 3.2, but for temperatures. Again, the deterioration produced by using a T+120 minute cutoff is frequently within the ±1% significance level and much less than the deterioration caused by using the older, 06Z run forecast. Nonetheless, most of the changes deteriorate the forecast and reach a maximum of 5% at 700hPa at T+24 in the tropics. This contrasts with WHL96, who found that using a T+90 minute cutoff lead to a deterioration of temperature RMS errors of up to 6% at T+12. As with WHL96 the impact on temperature is greatest in the lower atmosphere, as for winds. Again, verification against AIREPS and AMDARS leads to a similar conclusion.

3.1.2 RMS Errors Against Sondes and Surface Observations

Appendix B, Tables B.1-B.5, summarises the change in the RMS scores verified against upper air reports and surface observations. A negative change shows a reduction in the trial error; clearly most scores have deteriorated. The biggest deterioration is at short times, reducing as we go to T+120. After T+72 the deteriorations are mainly <1%. As we would expect, the deteriorations are not as severe as those found by WHL96.

At T+0 the trial RMS geopotential height error (Table B.1) is up to 7% worse than operational in the extratropics above 400hPa. The deterioration is particularly severe in the SH. Tropical RMS errors are up to 7% worse than operational; there is a low level maximum deterioration at 700hPa. By T+24 there is no significant change in the tropical scores; by T+72 the SH scores are similar in the trial and operational suites and in the NH and area 2 the scores become similar between T+96 and T+120. In the NH and area 2 the RMS errors are 2-4% worse at most levels at T+72.

At T+0, the NH and area 2 RMS temperature (Table B.2) errors are up to 10% worse above 200hPa. The trial scores have deteriorated by up to 6% in the tropics (all levels) and SH (around 400hPa). The trial and operational scores in the tropics and SH are similar by T+24. As the forecast range extends the deterioration in the NH and area 2 diminishes, but extends to more levels. At T+72 the errors are typically 1-2% worse. At T+120 there is no significant change in the scores for any area.

The RMS VWE's (Table B.4) are similar to the height and temperature errors. At T+0 the trial RMS VWE's are 2-6% worse in the extratropics, especially at upper levels. The deterioration in the tropical scores is more severe, ranging from 5-15%, but again peaking at upper levels. In the SH and area 2 the deterioration in the scores in generally <1% by T+24. The deterioration in the NH and tropical scores is now less than 2%. At T+96, there is no significant difference in the tropical scores. By T+120, the change in the NH scores is neutral. At late times the SH scores above 200hPa appear better in the trial than in the operational control. Fitting the analysis less closely to the observations may improve the forecast, but, since the improvement occurs at late times, it seems more likely that this is a random fluctuation.

At the surface, the deterioration in the RMS PMSL error (Table B.5) is generally small, especially in area 2 and the NH. At T+0 and T+24 the trial scores are worse in the SH, while in the NH the trial shows a significant deterioration only at T+72. The 10m winds and 1.5m temperatures show no significant change.

To summarise the nett impact of the trial, we have counted the number of RMS scores that have changed by more than 1%.

TABLE 3.2

Number of RMS scores verified against sondes and surface observations which have changed by more than 1% when using a cutoff of T+120 minutes.

Area	Trial better	Equal	Operational better	Total
Area 2	9	93	66	168
N Hemisphere	1	73	94	168
Tropics	6	107	55	168
S Hemisphere	13	101	54	168
Total	29	374	269	672

Table 3.2 shows that the trial deteriorates the forecast in all areas, especially the NH. This is a little surprising, as we might expect the data sparse SH to be more susceptible to changes in the data cutoff.

3.1.2 VERIFICATION AGAINST ANALYSES

Operational and trial verification against analyses use their own respective analyses. In the trial, where less data is assimilated, the analysis is thus closer to a short range forecast and perhaps smoother. The percentage change in the RMS scores is summarised in Appendix B (Tables B.6-B.10).

The verification against analysis tells a broadly similar story to verification against sondes and surface observations; early forecasts are degraded most, but beyond about T+72 there is little to choose between the trial and operational forecasts. Again, the deterioration is significantly less than that found by WHL96 with a T+90 minute cutoff; it is typically 2-3%, compared with up to 9% found by WHL96.

The trial PMSL RMS error (Table B.10) is worse than the operational error in area 2 before about T+80; at its worst it produces a 2% deterioration at T+72. The 10m wind only shows a deterioration in the NH and area 2, where the trial RMS VWE's are up to 2% worse than operational at early times. The 1.5m temperature at T+24 is 2% worse in the SH, but other than this the scores are neutral.

At T+24 RMS height errors (Table B.6) are worse than the control by up to 6% in area 2, and 3% in the NH and SH. The deterioration is mainly in upper levels. However, in the tropics the trial height errors are up to 10% better. The apparent improvement, which was not evident when verifying against sondes, may be due to the trial analyses being smoother. By T+48 the signal is similar, but of reduced strength. There is no significant difference between the trial and the operational verification by T+96 (not shown).

Temperature errors (Table B.7) are increased in all areas except the tropics, where they decrease by 5% at 100hPa. However, at 700hPa the tropical errors are 4% worse than in the trial. In other areas at T+24, the trial RMS temperature errors are up 4% worse than operational; this is typically in the upper troposphere. By T+96 the scores are mainly neutral. The upper level deterioration in area 2 at 200hPa persists until T+120, when the trial score is 3% worse than operational.

RMS VWE's (Table B.9) are all worse in the trial than in the operational control at T+24. The NH and area 2 show a 2% deterioration at all levels, while in the SH this deterioration only occurs above 600hPa. The tropics show a 2-3% deterioration between 700hPa and 200hPa. As the forecast range increases the signal deterioration reduces, until at T+96 only area 2 shows a significant deterioration in the trial. By T+120 all areas show a neutral change except low levels in area 2.

Similarly to Table 3.2, we can enumerate the number of scores that have changed by more than 1%. These counts are shown in Table 3.3. As with the verification against observations, the biggest degradations are in the NH and area 2, with the tropics and SH being equally spread between trial and operational.

TABLE 3.3

Number of RMS scores verified against analyses that have changed by more than 1% when using a cutoff of T+120 minutes.

Area	Trial better	Equal	Operational better	Total
Area 2	11	75	100	186
N Hemisphere	6	112	68	186
Tropics	33	121	32	186
S Hemisphere	20	138	28	186
Total	70	446	228	744

3.1.3 IMPACT ON COMPOSITE NWP INDEX

In order to estimate the impact on the NWP index, I, we will use the proxy, $\overline{I}$, as described in Hammon & Lorrimer (1996). Table 3.4 summarises the various components of $\overline{I}$ and the impact on trial on them. Again, there is degradation due to the trial; the trial index is 114.9, while the control index is 115.6. However, Table 2.4 shows that most of this deterioration comes from the NH. While the apparent improvement in the SH is small, and may be below the level of noise, the improvement in tropical winds at 850hPa for T+24 is quite large. As we discussed before, this apparent improvement may be due to verifying the forecast against a smoother analysis; the improvement is not apparent in the verification against radio sondes.

TABLE 3.4

Table showing break down NWP index proxy into its constituent parts for the T+120 minute cutoff trial and operational forecasts.

Area	Field	VT	W_i	E_i	$\overline{\varepsilon_i}$ control	$W_i E_i / \overline{\varepsilon_i}$ control	$\overline{\varepsilon_i}$ test	$W_i E_i / \overline{\varepsilon_i}$ test	$\Delta \overline{I}$
NH	PMSL	T+24	10	220.0	200.2	10.99	201.9	10.90	-0.09
NH	PMSL	T+48	8	350.0	330.9	8.46	334.3	8.38	-0.09
NH	PMSL	T+72	6	470.0	466.2	6.05	471.8	5.98	-0.07
NH	PMSL	T+96	4	570.0	599.3	3.80	601.3	3.79	-0.01
NH	PMSL	T+120	4	680.0	747.7	3.64	749.0	3.63	-0.01
NH	H500	T+24	6	15.9	15.5	6.17	15.7	6.08	-0.09
NH	H500	T+48	4	28.8	29.5	3.91	29.8	3.86	-0.04
NH	H500	T+72	2	42.8	44.3	1.93	44.8	1.91	-0.02
NH	W250	T+24	12	6.0	5.8	12.50	5.9	12.27	-0.23
Tropics	W850	T+24	5	3.3	2.2	7.58	2.1	7.69	0.11
Tropics	W850	T+48	3	4.3	3.0	4.32	3.0	4.29	-0.02
Tropics	W850	T+72	2	5.0	3.6	2.80	3.6	2.79	-0.01
Tropics	W250	T+24	6	5.2	3.9	8.08	3.9	7.94	-0.14
SH	PMSL	T+24	5	290.0	237.3	6.11	236.5	6.13	0.02
SH	PMSL	T+48	4	470.0	357.8	5.25	354.1	5.31	0.05
SH	PMSL	T+72	3	620.0	459.8	4.05	452.5	4.11	0.07
SH	PMSL	T+96	2	760.0	549.3	2.77	546.9	2.78	0.01
SH	PMSL	T+120	2	870.0	636.6	2.73	630.7	2.76	0.03
SH	H500	T+24	3	24.1	19.8	3.65	20.2	3.57	-0.07
SH	H500	T+48	2	42.4	33.7	2.51	33.9	2.50	-0.01
SH	H500	T+72	1	59.5	46.1	1.29	45.7	1.30	0.01
SH	W250	T+24	6	6.3	5.4	7.06	5.4	6.97	-0.09

3.1.4 VERIFICATION AGAINST AIREPS AND AMDARS

As we discussed in section 2, the biggest impact of reducing the data cutoff time is on the asynoptic data, in particular Air Rep and AMDAR observations. Most of these observations are clustered in the jets of the North Atlantic and, to a lesser extent, the North Pacific. As we have already noted, a significant degradation occurs in the forecasting of winds at jet levels. To test

this further we have also verified the forecasts against AIREPS and AMDARS.

The verification of temperatures against AMDARS (not shown) is noisy, making a quantitative estimate of the degradation difficult, especially in the SH, where there are typically only 80 observations per day at 250hPa, compared with 800 in the NH. Despite this, we are confident that a degradation of a few per cent in the RMS temperature errors does occur in the trial, especially at jet levels. The degradation seems to persist through to T+120. The signal in the wind verification is much clearer. At T+0, the RMS VWE's are degraded in the trial at all levels and in all areas. The degradation is worst at jet levels; in the tropics it reaches 6%, but 2-3% is more typical in the extra-tropics. After T+0 the signal drops, only reaching around 2% in all areas by T+24. There is no significant signal in the Tropics and SH by T+72 and in the NH and area 2 by T+96. Figure 3.9 shows the typical percentage impact in the RMS scores. Here, they are for area 2 at T+0 to T+120. These show a consistent deterioration always except at 300hPa for T+72 and T+120 at levels below 250hPa.

Similarly to the AMDAR verification, the verification of temperatures against AIREPS gives a noisy signal; at T+0 there is no clear signal in the SH and tropics. In the NH and area 2 there is a degradation in the RMS errors of 1-2%. In area 2 the deterioration persists through to T+120. The signal in the NH loses significance around T+72. In area 2, the NH and the tropics the RMS VWE's may be worse in the trial than operational from T+0 through to T+120. The deterioration varies between 1-4%; it shows no clear dependence on forecast range. The SH shows a clear deterioration in the trial out to T+48. At T+72 the change is neutral, but at T+96 and T+120 there is a noticeable improvement. This may again be due to noise. Alternatively, the smoother analysis may be leading to improvements in the forecast. The percentage impact in the RMS scores is shown in Figure 3.10 for T+00 and in Figure 3.11 for T+24.

3.2 One Hundred and Fifty Minute Cutoff

3.2.1 Short Period Forecasts

In most respects the verification of the forecasts with a T+150 minute cutoff are very similar to those with a T+120 minute cutoff, except that the signal is weaker. Figure 3.12 shows the percentage deterioration in the RMS VWE's at T+12 (solid line). The dotted line shows the deterioration found when verifying a T+18 run valid at the same time. Figure 3.13 shows the same thing for temperatures. The T+150 minute cutoff has a neutral impact, while the 06Z run has a large detrimental impact.

3.2.2 Verification Against Sondes and Surface Observations

The percentage changes in the RMS errors are summarised in Appendix C, Tables C1-C5.

Verification of heights (Table C1) is generally neutral, although there may be a deterioration at late forecast times in NH and area 2. The signal is only apparent for T+96 and T+120 and shows up to a 2% deterioration below 400hPa. This is quite a different signal to

that found in previous trials, where the maximum deterioration was at early forecast times. Therefore, we are dubious as to the general validity of this signal which may have arisen by chance.

The temperature RMS errors (Table C2) are difficult to assess. While there is a tendency for these to be degraded, there is no clear signal in most areas, except at T+0 in the Tropics, where the trial i up to 5% worse. However at later forecast times this degradation is not evident. We therefore conclude that temperatures are probably degraded by using a T+150 minute cutoff, but the signal is not strong enough for it to be quantified in this trial.

There is only a clear signal of degradation in the RMS VWE's (Table C4) at T+0 in the SH and tropics (see Figure 3.14). Both show a degradation throughout the depth of the atmosphere. The tropics peak at 6%, while in the SH the maximum degradation is 3%. In both areas the error is a maximum at around 250hPa. This worsening of rms errors is less than half that seen using a T+120 minute cutoff (cf Table B4) .

The PMSL RMS error (Table C5) shows a consistent deterioration of around 1.5% at all forecast ranges. The PMSL is also about 1.5% worse in area 2 at T+96 and T+120. There is no significant deterioration in either the 10m wind or the 1.5m temperature. These results are slightly better than the results using a T+120 minute cutoff.

As before, we have counted the number of RMS scores that have changed by more than 1%.

TABLE 3.5

Number of RMS scores verified against sondes and surface observations which have changed by more than 1% when the data cutoff is reduced to T+150.

Area	Trial better	Equal	Operational better	Total
Area 2	12	113	43	168
N Hemisphere	1	132	35	168
Tropics	23	118	27	168
S Hemisphere	8	104	56	168
Total	44	467	161	672

As we expected, Table 3.5 is more favourable to the T+150 minute trial than Table 3.2 is to the T+120 minute cutoff trial, with a greater proportion in the 'equal' category (<1%). However, the deterioration is still clear, especially in the SH. Much of the improvement, compared with the T+120 minute experiment, is in the NH and area 2.

3.2.3 VERIFICATION AGAINST ANALYSES

As with the T+120 minute cutoff, the verification against analysis tells a very similar story to the verification against observation; it is summarised in Appendix C, Tables C6-C10.

The RMS height errors (Table C6) deteriorate in both area 2 and the NH by up to 2%, although the change is neutral in area 2 by T+96 and in the NH by T+120. The tropical height errors show a consistent improvement of up to 4-5%. This improvement was not apparent in the verification against observations, but it was noted in the T+120 minute trial. Since the improvement does not appear against observations we suspect that the apparent improvement is due to the degraded verifying analysis, rather than any real improvement in the forecast; sampling differences may also be significant.

At T+24 and T+48 the trial shows degradations in the temperature RMS errors (Table C7) . These are restricted to the NH and area 2, where the maximum degradation is around 3% in the upper troposphere. All other areas and times show deteriorations that are generally $<1\%$.

In the T+120 minute trial the RMS VWE's (Table B9) showed the most significant degradation. Using a 150 minute cutoff again shows a significant degradation, but it does not stand out here. The deteriorations are restricted to the NH and area 2 at T+24, T+48 and T+72 (Table C9) . There is also some evidence of a degradation in the tropics at T+24 only. The maximum errors are again at jet levels. However, the maximum error, of about 2%, is not reached until T+48 (see Figure 3.15).

We will again use two methods to summarise the impact of this change in the data cutoff time. First, Table 3.7 enumerates the number of scores that have changed by more than 1% in either direction.

TABLE 3.7

Number of RMS scores verified against analyses that have changed by more than 1% using a 150 minute cutoff.

Area	Trial better	Equal	Operational better	Total
Area 2	3	149	34	186
N Hemisphere	0	135	51	186
Tropics	52	118	16	186
S Hemisphere	4	165	17	186
Total	59	567	118	744

Table 3.7 shows that the change in the scores when using a 150 minute cutoff is smaller than when using a 120 minute cutoff. However, perhaps the most startling result is the apparent

improvement in the tropics, which we discussed above.

We have also calculated the NWP index proxy, $\overline{I}$, for this period. For the control $\overline{I}=113.0$ and for the trial $\overline{I}=112.3$, an overall deterioration of 0.7. This is the same as we found for the T+120 minute trial. In Table 3.8 we break this down into its constituent scores.

TABLE 3.8

Table showing break down NWP index proxy into its constituent parts for the T+150 minute cutoff trial and operational forecasts.

Area	Field	VT	W_i	E_i	$\overline{\varepsilon_i}$ control	$W_i E_i / \overline{\varepsilon_i}$ control	$\overline{\varepsilon_i}$ test	$W_i E_i / \overline{\varepsilon_i}$ test	$\Delta \overline{I}$
NH	PMSL	T+24	10	220.0	187.3	11.75	188.6	11.67	-0.08
NH	PMSL	T+48	8	350.0	308.4	9.08	312.1	8.97	-0.11
NH	PMSL	T+72	6	470.0	446.3	6.32	453.5	6.22	-0.10
NH	PMSL	T+96	4	570.0	614.4	3.71	620.1	3.68	-0.03
NH	PMSL	T+120	4	680.0	742.9	3.66	749.0	3.63	-0.03
NH	H500	T+24	6	15.9	14.4	6.61	14.5	6.57	-0.03
NH	H500	T+48	4	28.8	27.2	4.24	27.4	4.20	-0.03
NH	H500	T+72	2	42.8	43.1	1.99	43.9	1.95	-0.04
NH	W250	T+24	12	6.0	5.8	12.36	5.9	12.20	-0.15
Tropics	W850	T+24	5	3.3	2.2	7.53	2.2	7.56	0.02
Tropics	W850	T+48	3	4.3	3.0	4.34	3.0	4.32	-0.01
Tropics	W850	T+72	2	5.0	3.5	2.85	3.5	2.83	-0.01
Tropics	W250	T+24	6	5.2	4.1	7.67	4.1	7.55	-0.11
SH	PMSL	T+24	5	290.0	250.0	5.80	247.3	5.86	0.06
SH	PMSL	T+48	4	470.0	411.5	4.57	410.5	4.58	0.01
SH	PMSL	T+72	3	620.0	581.2	3.20	582.1	3.20	0.00
SH	PMSL	T+96	2	760.0	704.4	2.16	711.1	2.14	-0.02
SH	PMSL	T+120	2	870.0	789.2	2.20	801.6	2.17	-0.03
SH	H500	T+24	3	24.1	21.8	3.32	21.7	3.33	0.02
SH	H500	T+48	2	42.4	40.1	2.11	40.2	2.11	0.00
SH	H500	T+72	1	59.5	60.5	0.98	60.5	0.98	0.00
SH	W250	T+24	6	6.3	5.7	6.61	5.8	6.57	-0.04

Comparing this table with that for the T+120 minute trial, the T+150 minute cutoff deteriorates

the wind components less, but the other scores in the NH deteriorate by a greater amount. The T+120 minute trial produces a poorer index in the SH. However, many of these changes are in the noise.

3.2.4 Verification Against AMDARS and AIREPS

In §3.1.4 we commented that the change in the verification against AMDARS and AIREPS was very noisy. This is still true here. Much of the signal is at the noise level, which we suspect is significantly greater than the assumed 1%. The only clear signals are that the verification of tropical winds against AMDARS and the verification of NH winds against AIREPS have both deteriorated by a few per cent. Verification against AMDARS provides the better verification; this shows that there is a consistent deterioration in RMS VWE's at T+00 (Figure 3.16) of around 2%, although this varies from 0.5% in area 2 to 6% in the SH upper atmosphere. At T+24; the amplitude of the deterioration has decreased significantly, the maximum being only around 2% (Figure 3.17). There is no clear signal in the tropics.

3.3 Comparison of LAM and Global Model Verification

Part of a possible technical solution to the NWP user requirement is the replacement of the LAM with a high resolution global model. While we will study the impact of enhancing the resolution of the global model in a later parallel trial, it is useful to compare the Global and LAM verification now. However, this comparison is limited by two inconsistencies in the verification process:

1. Since the observations for verification are obtained by intercepting the OPD, the observations used for verifying the LAM and Global models are different.
2. The LAM is verified on its own grid, with a resolution of approximately 25 minutes of arc, or 50km at mid-latitudes. The Global model results are first smoothed and filtered to convert from its own 1.25° grid to a 2.5° grid. The verification grid has a resolution of approximately 180km at mid-latitudes. These smoothed fields are then verified.

Of the two differences, we suspect that the latter will have the biggest systematic impact. Smoothed fields have a systematically lower RMS error. So, the comparison will be unfairly weighted in favour of the global model. Some typical results are shown in Figure 3.18. The left-hand panels show the bias, and the right-hand panels the RMS errors. The errors from the operational global model (solid line), the T+120 minute trial (dashed line) and the operational LAM (dotted line) are shown. The results are for verifying PMSL and 1.5m temperature over the full LAM area (area 888) and the UK & Iceland (area 5). The time when the LAM scores become worse than the global model scores is dependant on both the field being verified and the area over which it is verified, but between T+6 and T+24 is usual and T+18 is typical.

The change over at T+18 seems unreasonably short, as a synoptic scale system will typically take longer than this to cross the LAM area. We believe that the results are dominated by the smoothing described in point 2 above. So, we can interpret this as a lower limit on the usefulness of the LAM, *ie,* the LAM is typically more useful than the global model for at least the first 18 hours. Further, the primary use of the LAM is determining the precipitation patterns

at T+18 and beyond. We have made no attempt to compare the precipitation forecast. This will be addressed during the global high resolution parallel trial.

3.4 Impact of Intermediate Forecast Runs

In sections 3.1.1 and 3.1.2 we compared the short period forecasts with an 06Z global model run. In those sections we regarded the 06Z run as the maximum deterioration that could be produced by shortening the cutoff times. However, it also has relevance to assessing the possible value of an intermediate global run. This has been previously considered by Adams (1995). She showed that potentially large improvements in forecast quality were available if an update run was available in preference to the main run. For instance, she found improvements in the 250hPa RMS VWE of over 20% were possible if a T+6 forecast were used in place of a T+12 forecast.

The difference between the 06Z and 12Z parallel trial runs gives us some indication of the likely impact of an update run of the global model. The large impact is clear in Figure 3.1. We could expect improvements of around 10% are possible if a T+12 forecast is available in preference to a T+18 forecast. Our verification is not as temporally complete as that of Adams (1995) and so it is difficult for us to conclude anything other than our general agreement with the magnitude of the results found by her.

3.5 Summary of Verification

The overall signal from the verification is that reducing the data cutoff time leads to significant deteriorations in the forecasts of most fields. The change is mainly neutral by T+72. However, using a cutoff of 120 minutes or longer gives better results than were found by WHL96 using a 90 minute cutoff. The most worrying degradation produced by shortening the cutoff time is to the jet level winds. It is also consistent with WHL96. There are some significant benefits to using a 150 minute cutoff rather than a 120 minute cutoff. In particular the jet level winds are better.

4. Subjective Assessment of Early Cut-Off Trials

4.1 Early Cut-Off Trial At T+120 Minutes - Trial Period 19/02/96 - 06/03/96

4.1.1 Analyses

The largest differences between trial and operational analyses were due to small changes in the strength of jets and in the position and depth of depressions. In the North Atlantic, differences were minimal, with 250hPa wind differences less than $2ms^{-1}$ and small mean sea level pressure differences confined to north of 65N. Similar small differences occurred more frequently over the North Pacific. However, the most significant differences in the Northern Hemisphere were seen over Northern India, East Pakistan and the Himalayas, with an occasionally marked impact on the subtropical jet. A typical example is shown in Figure 4.1, where the trial maximum wind speed of $64ms^{-1}$ (Figure 4.1a) is $10ms^{-1}$ weaker than the operational peak wind speed (Figure 4.1b). The largest differences in the Northern Hemisphere were due to the large numbers of late AIREPS or AMDARS missed by the trial assimilation.

Differences between the analyses in the Southern Hemisphere were larger and more frequent, especially south of 50S., with occasional mean sea level pressure differences of 5-10hPa. Figure 4.2 shows a typical difference seen between the trial and operational analyses of a depression. In the Southern Hemisphere, the largest differences were due to synops, sondes, SATEMS and drifting buoys.

4.1.2 Forecast Evolution

Daily comparison of trial and operational forecasts during the parallel suite trial showed no changes of evolution in the Northern Hemisphere but there were some differences in detail at day 3 onwards. Differences in the forecast over the U.K. were insignificant. Most differences in mean sea level pressure even at day 5 were due to small changes in timing and in the position, depth and gradient of troughs and depressions. Assessment of significant differences (>8hPa) at day 5 strongly favoured the operational forecasts in the Northern Hemisphere but in the Southern Hemisphere assessment was neutral. The following examples illustrate some of the largest differences seen during the trial and indicate the slight degradation in most trial forecasts.

a) Eastern Atlantic / UK area 12Z 09/03/96

The largest impact seen in the Eastern Atlantic during the trial is indicated in the difference chart shown in Figure 4.3c. These differences in the mean sea level pressure forecast for day 5 were due to changes in the forecast depth and position of a depression to the southwest of Ireland. The verifying analysis for 12z 09/03/96 is shown in Figure 4.3d. In this case assessment is fairly even, with the position of the depression slightly closer in the trial forecast, Figure 4.3a, but the forecast pressure over Ireland more accurate in the operational forecast, Figure 4.3b.

In the trial 500hPa forecast for day 5 , Figure 4.4a, the depth of the cold pool (518dm) to the southwest of Ireland was too deep when compared to the verifying analysis shown in Figure 4.4d. The operational cold pool, depth 528dm, shown in Figure 4.4b, was much closer to the analysis.

b) Northwest Pacific / Bering Sea 12Z 03/03/96

Several differences between trial and operational depressions were noticed in the Northwest Pacific and Bering Sea during the trial and a typical example is shown in Figure 4.5. The analysis for 12Z 03/03/96, Figure 4.5d, shows a depression, 979hPa, centred to the south of the Kamchatka peninsula. The depth and position of this depression was more accurately predicted by the day 5 operational forecast, Figure 4.5b. In the trial forecast. Figure 4.5a, the depression was too far north and not deep enough.

c) Northeast Pacific / Alaska 12Z 27/02/96

Some of the largest differences in forecast mean sea level pressure at day 5 were seen in the Northeast Pacific close to Alaska and Western Canada. The verifying analysis for 12Z 27/02/96, Figure 4.6d, shows a depression, depth 983hPa, centred just south of the Aleutian Islands. The position of this depression was very well predicted by both the trial and operational

day 5 forecasts. However, the trial depression, Figure 4.6a, was 10hPa too deep. Similarly, the small depression to the west was better predicted in the operational forecast, Figure 4.6b. The trial and operational T+120 500hPa forecasts are compared in Figures 4.7 a/b respectively. The trial cold pool, 508dm, to the south of the Aleutian Islands was much too deep when compared to the operational forecast, 516dm, and the verifying analysis 522dm in Figure 4.7d.

d) Southern Hemisphere / New Zealand 12Z 03/03/96

In the Southern Hemisphere, the largest differences in mean sea level pressure were often found between New Zealand and Cape Horn, possibly due to the large number of SATEMS and SATOBS missed by the trial analysis. However, not all of these comparisons were detrimental to the trial forecasts. The analysis for 12Z 03/03/96, Figure 4.8d, shows a deep depression, 982hPa, centred east of New Zealand. The trial depression, Figure 4.8a, was slightly deeper and closer to the verifying analysis.

4.1.3 Forecast Jets T+24

There was some impact upon jets at T+24 in both the Northern and Southern Hemispheres as a result of the large number of aircraft and satellite observations missed by the early cutoff at 120 minutes. Impact on winds across the Atlantic was slight, but strong jets across the Atlantic were not a significant feature of this period. The main impact was seen in the subtropical jet over China and also in the Northeast Pacific and Western Canada between 45N and 60N. Assessment of significant differences ($>5ms^{-1}$) strongly favoured the operational forecasts in the Northern Hemisphere, but in the Southern Hemisphere assessment was more neutral.

a) North Pacific jet 12Z 26/02/96

The 250hPa wind analysis for 12Z 26/02/96, Figure 4.9d, features a strong west to northwesterly jet over the Alaskan Peninsula, with the maximum wind speed of $61ms^{-1}$ probably slightly underestimated. The trial and operational day 1 forecasts of this jet are compared in Figures 4.9 a/b respectively. The trial forecast of this jet was slightly weaker with a secondary jet further south which is not shown in the verifying analysis, Figure 4.9d, and the stronger, smoother operational forecast is preferred.

b) Norwegian jet 12Z 05/03/96

The analysis in Figure 4.10d shows a northerly jet over Norway with maximum wind speed $64ms^{-1}$. The biggest difference in the day 1 jets in the vicinity of the U.K. was associated with this jet (see Figure 4.10c). The operational day 1 forecast, Figure 4.10b, had a more accurate representation of this jet. The trial T+24 jet, Figure 4.10a, was weaker, with the $50ms^{-1}$ isotach still mainly to the west of Norway.

4.2 Early Cut-Off Trial At T+150 Minutes - Trial Period 08/03/96 - 31/03/96

4.2.1 Analyses

Significant differences between trial and operational analyses were slightly less than those seen in the T+120 minute trial in the Northern Hemisphere, but very similar in the Southern Hemisphere. Marked differences between the mean sea level pressure analyses were confined to the Southern Hemisphere to the south of 50S and most could be linked to late observations from drifting buoys, SATEMS and ships, with late synops and sondes important over Antarctica. As in the T+120 minute trial, the largest differences between trial and operational analyses were due to small differences in the jets and in the depth and position of depressions. One of the largest differences between the mean sea level pressure analyses is shown in Figure 4.11c associated with the depression to the west of Cape Horn at 12Z 08/03/96. The trial and operational 250hPa wind analyses for this time are compared in Figure 4.12 a/b respectively, illustrating typical small differences between the analysed jets .

In the Northern Hemisphere, the different numbers of AIREPS and AMDARS used in the trial and operational assimilations meant that the biggest impact was seen in the upper winds, often associated with small differences in the jet analyses. In the North Atlantic, the impact was minimal ($<2ms^{-1}$), but occasional larger differences were seen in the North Pacific and over the Himalayas.

4.2.2 Forecast Evolution

Although the impact of the early cutoff of data at T+150 minutes was minimal on the forecast evolution in the Northern Hemisphere, differences in detail were noticed after three days into the forecast. On the whole, these differences were less than in the previous trial (T+120 minute cutoff). Most differences were due to small changes in timing and in the depth and position of depressions and troughs. Assessment of significant differences (>8hPa) in the Northern Hemisphere mainly favoured the operational forecasts.

Differences in the Southern Hemisphere were larger and more frequent with some evolution changes at T+96 onwards. Assessment of the significant differences slightly favoured the operational forecasts. The first two examples show the largest differences between trial and operational forecasts in the eastern Atlantic during this trial.

a) Eastern Atlantic 12Z 18/03/96

The main feature in the analysis for 12Z 18/03/96, Figure 4.13c, is a large depression centred west of Ireland. Both the trial and operational day 5 forecasts, compared in Figures 4.13 a/b respectively, had a fast timing error, with the main features moved too far east. The predicted ridge at 15-20W is also incorrect. These errors were slightly larger in the trial forecast.

b) Eastern Atlantic 12Z 01/04/96

This case is typical of many differences seen between trial and operational forecasts at

day 5 in this trial. The forecast evolution is the same, but there was a small difference in the depth and position of the main depression, with the operational depression, Figure 4.14b, being slightly deeper and further north. The verifying analysis, Figure 4.14d, shows that the depression was centred over the Pyrenees at 12Z 01/04/96, so both forecasts had a positional error. The trial forecast, Figure 4.14a, verified better over Southern England in this case.

c) Southern Hemisphere 12Z 27/03/96

In this case, both the trial and operational 5 day forecasts over-deepened a trough at 45S 30E, just west of Prince Edward Island in the south Indian Ocean. The trial forecast in particular, Figure 4.15a, developed a small deep depression 987hPa. Although the analysis for 12Z 01/04/96, Figure 4.15d, showed minor troughs, there was no indication of a major development in this area.

d) New Zealand 12Z 16/03/96.

Several differences in the 5 day forecast were seen over New Zealand, which may be partly attributed to the large numbers of SATOBS and SATEMS missed by the trial early cutoff. The verifying analysis for 12Z 16/03/96, Figure 4.16d, shows a deep depression, 986hpa, centred east of South Island. The trial and operational 5 day forecasts, compared in Figures 4.16 a/b respectively, both showed a significant timing error in developing an anticyclone over New Zealand for this time. Subjectively, the trial forecast is preferred, since it predicted a deep depression to the west of South Island, albeit 10 degrees too far east.

4.2.3 Forecast Jets T+24

As in the T+120 early cutoff trial, there was some impact on jets in the Northern and Southern Hemisphere due to the large numbers of AMDARS and AIREPS missed by the trial assimilation. The impact in the Northern Hemisphere was minimal over the North Atlantic ($<2ms^{-1}$), but more noticeable over the North Pacific and Asia. Differences were usually small at day 1, often too small to be assessed subjectively although they could have had an impact upon the objective scores. Where the few larger differences could be judged with confidence, assessment favoured the operational jets.

a) Subtropical jet over the Himalayas. 12Z 24/03/96

This case shows a typical example of small differences in the day 1 forecast of the subtropical jet over the Himalayas. The jets are very similar, but there was extra detail in the operational forecast, Figure 4.17b, but the differences were too small to be assessed.

b) North Pacific jet 12Z 28/03/96

The 250hPa wind analysis for 12Z 15/03/96, Figure 4.18d, features a strong westerly jet over the North Pacific, with maximum wind speed $75ms^{-1}$. The trial and operational T+24 forecasts of this jet are compared in Figures 4.18 a/b respectively. Both forecasts underestimated the strength of the jet core but the slightly stronger operational jet was preferred.

5. SUMMARY

5.1 DATA RECEIPT

1. In the Northern Hemisphere, the most important issue was the number of AMDARS and AIREPS omitted in the early cut-off analyses, which had a slight detrimental impact on the upper wind analyses and subsequent T+24 forecast aviation winds. 80% of the total AMDARS and AIREPS used in the operational assimilation were not received until T+135/140 minutes.

2. In the Tropics, a cut-off time of T+135/140 minutes would include many synops and sondes omitted by the T+120 minute cut-off. A cut-off at T+145 minutes would include many SATOBS from the Indian satellite, if these are needed.

3. In the Southern Hemisphere, the important data were late synops, AMDARS, drifting buoys and SATEMS. A cut-off time of T+135/140 minutes would include many synops omitted by the T+120 minute cut-off.

5.2 OBJECTIVE ASSESSMENT

1. Both the T+120 and T+150 minute cutoffs degrade the operational forecast, although by less than the T+90 minute cutoff studied by WHL96.

2. The jet level winds at short periods are the most seriously degraded, especially in the T+120 minute trial.

3. The verification against analyses is apparently improved in the tropics. This is due to the verifying analyses being smoother, rather than any genuine improvement in forecast quality.

4. Both trials deteriorated the NWP index by 0.7.

5.3 SUBJECTIVE ASSESSMENT

1. Both the T+120 and the T+150 minute cut-off trials were significantly better than the T+90 minute cut-off trial. The T+150 trial was slightly better than the T+120 trial.

2.The impact of the early cut-off trials over the U.K. was small but this may have been partly due to the blocking pattern.

3. In the Northern Hemisphere, forecast evolution at day 5 from the trial forecasts, was similar to the operational evolution and differences were mainly due to small changes in timing and the depth and position of depressions and troughs. In the Southern Hemisphere, differences were larger, with some evolution changes.

4. The main problem in the Northern Hemisphere was the slight degradation in the T+24 aviation winds, caused by late Air Reps and AMDARS missing the earlier cutoff of data at T+120 and T+150 minutes. The main impact was seen over the North Pacific and Himalayas.

Differences in the winds in the T+150 trial were often too small to be assessed subjectively but they would have an impact on objective scores.

5.4 TROPICAL CYCLONES

A summary of the verification of the 8 tropical cyclones active during the whole period of the parallel trial is given in Appendix D. There was a large increase in analysis error, reflecting the lack of data in the earlier cut-off. This may be due to omission of real or bogus data. The bogus data is based on advisory bulletins from warning centres at Miami and Honolulu (for the Atlantic and Central Pacific oceans) and at Guam for all other areas. The warnings from Miami and Honolulu are valid at 03Z, 09Z, 15Z etc However the Guam advisories are valid at 00Z,06Z,12Z etc and are usually received at betweeen 2h 30 minutes and 3 hours after the main synoptic hour. During the period of the trial advisories were received in time to create bogus data on 16 occasions for the operational suite but only on 7 occasions in the parallel suite. The lack of bogus data is likely to have contributed significantly to the increased analysis error.

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REFERENCES

Hammon, O.M. & Lorrimer, S.J., 1996, 'Parallel trial of outstanding 3CV Physics, correction of Boundary Layer Scheme and revision of orography ancillary files', NWP Technical Note No. 188.

Adams, W., 1995, 'The Impact of Introducing Intermediate Forecast Runs for Aviation', CF2 Aviation Services Report.

Wilson, C.A., Hammon, O.M. & Leighton, J.R., 1996, 'Trial of an Early Data Cut-off (T+90 Minutes) in the Global Model', NWP Technical Note No. 190

APPENDIX A

TABLE 2.1.

Total data received at 12Z by T+200 minutes, plus the fraction of data received by T+90 minutes, T+120 minutes and T+150 minutes. The period is 19/02/96-28/03/96

DATA	TOTAL NO.	T+90	T+120	T+150
SYNOPS	184764	0.922	0.948	0.974
AMDARS	101198	0.662	0.726	0.811
SATOBS	73957	0.530	0.622	0.886
AIREPS	36848	0.593	0.664	0.817
DRIBU	34001	0.577	0.694	0.813
SATEM	27816	0.605	0.785	0.871
SHIPS	22404	0.849	0.908	0.958
SONDE	20357	0.528	0.837	0.938
MORBU	4051	0.911	0.945	0.981
PLAT/RIG	668	0.954	0.991	1.000
TOTAL	506064	0.729	0.803	0.898

TABLE 2.2

Total data received at 00Z by T+200 minutes, plus the fraction of data received by T+90 minutes, T+120 minutes and T+150 minutes. The period is 19/02/96-28/03/96

DATA	TOTAL NO.	T+90	T+120	T+150
SYNOPS	167813	0.909	0.933	0.977
AMDARS	136652	0.624	0.724	0.837
SATOBS	86635	0.588	0.691	0.926
AIREPS	28041	0.654	0.724	0.837
DRIBU	29009	0.638	0.744	0.843
SATEM	25211	0.706	0.796	0.859
SHIPS	21466	0.873	0.920	0.965
SONDE	21709	0.503	0.848	0.938
MORBU	5874	0.878	0.929	0.970
PLAT/RIG	432	0.995	0.998	1.000
TOTAL	522842	0.724	0.795	0.903

APPENDIX B SUMMARY OF RMS SCORES FROM T+120 MINUTE CUTOFF EXPERIMENT

Table B.1 Percentage change in RMS height scores verified against sondes. A negative change indicates that the trial is an improvement.

Table B.2 Percentage change in RMS temperature scores verified against sondes. A negative change indicates that the trial is an improvement.

Table B.3 Percentage change in RMS relative humidity scores verified against sondes. A negative change indicates that the trial is an improvement.

Table B.4 Percentage change in RMS VWE's verified against sondes. A negative change indicates that the trial is an improvement.

Table B.5 Percentage change in RMS scores verified against surface observations. A negative change indicates that the trial is an improvement.

Table B.6 Percentage change in RMS height scores verified against analyses. A negative change indicates that the trial is an improvement.

Table B.7 Percentage change in RMS temperature scores verified against analyses. A negative change indicates that the trial is an improvement.

Table B.8 Percentage change in RMS relative humidity scores verified against analyses. A negative change indicates that the trial is an improvement.

Table B.9 Percentage change in RMS VWE's verified against analyses. A negative change indicates that the trial is an improvement.

Table B.10 Percentage change in RMS scores for surface parameters verified against analyses. A negative change indicates that the trial is an improvement.

TABLE B.1

Verification against sondes
Period= 19/02/96-08/03/96

Height
AREA 2

	T+00	T+24	T+72	T+120
850.0	0.6	0.7	4.3	1.5
700.0	-0.1	0.2	3.6	1.2
500.0	-0.7	0.2	3.1	0.8
300.0	-0.5	1.3	2.1	0.7
250.0	0.2	1.4	1.6	0.6
200.0	-0.6	0.6	1.6	0.0
100.0	0.2	0.9	1.9	-1.7
50.0	2.6	0.9	1.3	-1.7
Mean	0.2	0.8	2.4	0.2

NH

	T+00	T+24	T+72	T+120
850.0	-0.5	0.9	2.5	0.8
700.0	-0.2	1.0	2.2	0.4
500.0	0.9	1.1	2.1	-0.1
300.0	2.0	2.7	1.9	-0.4
250.0	1.5	2.5	2.0	-0.2
200.0	1.2	2.5	2.4	-0.3
100.0	1.8	1.5	1.9	-1.1
50.0	5.7	3.5	1.7	-0.6
Mean	1.6	2.0	2.1	-0.2

TROPICS

	T+00	T+24	T+72	T+120
850.0	0.6	-0.2	1.1	0.2
700.0	3.6	1.2	1.2	0.8
500.0	1.8	1.3	0.7	0.4
300.0	0.6	0.7	-0.4	0.4
250.0	0.6	1.0	-0.5	0.1
200.0	1.4	0.8	-0.3	-0.2
100.0	2.1	1.0	-0.1	0.4
50.0	7.1	0.1	0.6	0.9
Mean	2.2	0.7	0.3	0.4

SH

	T+00	T+24	T+72	T+120
850.0	-1.1	1.5	1.0	-0.6
700.0	2.9	2.8	-0.1	-0.4
500.0	4.6	4.2	-0.2	-0.1
300.0	7.3	3.5	0.3	0.5
250.0	7.1	2.8	0.0	0.1
200.0	4.0	2.5	-0.1	0.3
100.0	1.4	1.1	0.1	0.1
50.0	1.4	2.1	0.8	0.8
Mean	3.5	2.6	0.2	0.1

TABLE B.2

Verification against sondes
Period= 19/02/96-08/03/96

Temperature
AREA 2

	T+00	T+24	T+72	T+120
850.0	-0.3	-0.6	1.7	0.0
700.0	-0.7	0.5	1.5	0.4
500.0	0.3	1.2	1.2	0.7
300.0	-0.1	-0.7	1.3	-1.0
250.0	-0.3	-1.6	1.7	0.3
200.0	-0.5	0.2	1.5	0.9
100.0	6.1	0.3	1.2	1.3
50.0	4.7	1.7	3.6	0.4
Mean	1.2	0.1	1.7	0.4

NH

	T+00	T+24	T+72	T+120
850.0	1.5	0.4	1.0	-1.0
700.0	1.4	1.6	1.5	-0.5
500.0	3.1	1.8	0.8	0.3
300.0	1.1	0.5	2.2	1.8
250.0	1.6	-0.2	1.5	1.8
200.0	1.1	0.9	1.3	1.0
100.0	7.3	0.8	1.0	0.8
50.0	9.9	4.0	1.6	1.4
Mean	3.4	1.2	1.4	0.7

TROPICS

	T+00	T+24	T+72	T+120
850.0	6.6	-0.1	0.0	-0.6
700.0	8.5	1.5	0.3	0.8
500.0	4.2	2.1	0.0	0.0
300.0	6.6	0.2	-0.3	0.0
250.0	7.2	0.3	0.0	-1.8
200.0	10.4	1.2	0.7	1.3
100.0	-0.4	-0.7	-1.4	0.4
50.0	4.5	0.7	1.7	0.0
Mean	6.0	0.7	0.1	0.0

SH

	T+00	T+24	T+72	T+120
850.0	0.7	1.3	0.0	0.2
700.0	0.9	1.0	0.4	-1.3
500.0	3.5	0.4	0.2	1.9
300.0	6.5	-2.0	0.5	-2.0
250.0	2.6	0.5	0.0	1.0
200.0	1.7	1.0	0.9	-0.6
100.0	1.1	1.7	-0.4	-0.7
50.0	0.5	0.5	0.3	0.6
Mean	2.2	0.6	0.2	-0.1

TABLE B.3

Verification against sondes
Period= 19/02/96-08/03/96

Relative humidity
AREA 2

	T+00	T+24	T+72	T+120
850.0	0.3	-0.4	-0.6	-1.1
700.0	0.9	-0.3	0.7	-2.0
500.0	0.8	0.3	1.5	-0.3
Mean	0.7	-0.1	0.5	-1.1

NH

	T+00	T+24	T+72	T+120
850.0	1.7	0.2	0.0	-0.6
700.0	3.2	0.6	0.5	-0.6
500.0	6.0	0.8	1.4	0.2
Mean	3.6	0.5	0.6	-0.3

TROPICS

	T+00	T+24	T+72	T+120
850.0	11.6	1.4	1.3	0.4
700.0	22.7	2.2	1.5	0.5
500.0	24.4	4.2	1.1	-0.8
Mean	19.6	2.6	1.3	0.0

SH

	T+00	T+24	T+72	T+120
850.0	1.1	0.8	-0.6	-0.2
700.0	4.2	0.2	0.2	0.5
500.0	6.5	2.4	-1.3	-2.5
Mean	3.9	1.1	-0.6	-0.7

TABLE B.4

Verification against sondes
Period= 19/02/96-08/03/96

Wind
AREA 2

	T+00	T+24	T+72	T+120
850.0	0.1	0.2	1.7	0.6
700.0	0.4	0.2	1.9	0.5
300.0	-1.3	0.6	2.0	-0.3
250.0	-1.5	0.5	1.3	-0.5
200.0	-0.3	1.4	0.9	-0.5
100.0	3.1	0.8	1.3	-0.6
Mean	0.1	0.6	1.5	-0.1

NH

	T+00	T+24	T+72	T+120
850.0	1.2	0.8	0.8	0.4
700.0	2.8	1.5	1.1	0.3
300.0	3.5	1.8	1.9	0.5
250.0	3.5	1.7	2.1	0.5
200.0	3.0	1.8	2.1	1.1
100.0	6.2	1.5	1.3	0.1
Mean	3.4	1.5	1.6	0.5

TROPICS

	T+00	T+24	T+72	T+120
850.0	5.9	0.5	0.8	0.4
700.0	13.7	1.4	0.6	0.7
300.0	17.4	0.2	2.0	1.5
250.0	15.6	0.3	1.4	1.4
200.0	15.8	1.8	-0.1	0.5
100.0	11.6	1.5	0.0	-1.3
Mean	13.3	1.0	0.8	0.5

SH

	T+00	T+24	T+72	T+120
850.0	3.7	0.8	0.3	0.6
700.0	3.1	0.8	-0.5	0.5
300.0	2.3	0.5	-1.0	-0.4
250.0	3.7	-0.9	-0.5	-1.1
200.0	4.5	0.1	-0.1	-0.8
100.0	2.2	0.9	-1.3	-1.7
Mean	3.3	0.4	-0.5	-0.5

TABLE B.5

Verification against surface obs
Period= 19/02/96-08/03/96

PMSL
AREA 2

T+00	T+24	T+72	T+120
0.2	0.4	3.5	0.4

NH

T+00	T+24	T+72	T+120
-0.8	0.7	2.1	0.3

TROPICS

T+00	T+24	T+72	T+120
0.2	-1.4	0.8	1.1

SH

T+00	T+24	T+72	T+120
1.1	2.2	0.3	-0.9

1.5m Temperature
AREA 2

T+00	T+24	T+72	T+120
0.1	0	0.2	1.2

NH

T+00	T+24	T+72	T+120
0.2	0	0.4	0

TROPICS

T+00	T+24	T+72	T+120
0.9	0.5	0.4	0.4

SH

T+00	T+24	T+72	T+120
0.7	0.4	0.3	0.7

10m Wind
AREA 2

T+00	T+24	T+72	T+120
0	0.1	1.2	1.8

NH

T+00	T+24	T+72	T+120
-0.2	0.3	0.7	0.9

TROPICS

T+00	T+24	T+72	T+120
0.3	0	0.1	0.5

SH

T+00	T+24	T+72	T+120
0.1	0.3	-0.8	0

TABLE B.6

Verification against analyses
Period= 19/02/96-08/03/96

Height
AREA 2

	T+24	T+72	T+120
850	1.1	2.7	-0.5
700	1	3.1	-0.7
500	1.4	2.9	-0.8
300	1.7	2.7	-0.8
250	0.9	2.5	-1.1
200	1	2.7	-2.1
100	5.5	4.9	-3.2
50	6.1	2.9	-1.9
Mean	2.3	3.1	-1.4

NH

	T+24	T+72	T+120
850	1	1.2	-0.3
700	1.1	1.3	-0.7
500	1.5	1.1	-0.8
300	2.2	0.9	-0.9
250	2.1	0.8	-0.9
200	2.1	0.9	-1.1
100	2.3	1.5	-1.3
50	2.6	0.1	-2
Mean	1.9	1.0	-1.0

TROPICS

	T+24	T+72	T+120
850	-2.7	1	-0.9
700	-4.7	-0.8	-1.9
500	-2.1	-0.4	-2
300	1.3	1.6	-0.5
250	2.3	1.2	-0.8
200	2.7	0.4	-1.1
100	-0.2	0	-1.2
50	-10.2	-3.8	-2.2
Mean	-1.7	-0.1	-1.3

SH

	T+24	T+72	T+120
850	-0.4	-1.6	-1
700	0.4	-1.4	-0.5
500	2	-1	0.2
300	2.9	-0.6	0.5
250	2.9	-0.3	0.4
200	3.2	-0.1	0.3
100	3	-0.3	-0.2
50	1.5	-0.2	0.1
Mean	1.9	-0.7	-0.0

TABLE B.7

Verification against analyses
Period= 19/02/96-08/03/96

Temperature
AREA 2

	T+24	T+72	T+120
850	0.3	1.6	-1.1
700	1.9	2	-0.8
500	1.7	2.2	0.9
300	-1	-0.1	-1.5
250	1.4	1.6	1.7
200	1.8	2	3
100	5	1.6	2
50	2.9	4	-0.5
Mean	1.8	1.9	0.5

NH

	T+24	T+72	T+120
850	1.3	0.8	-0.5
700	0.9	0.5	-0.6
500	1.7	1	0.4
300	0.2	0.9	0.4
250	1.1	0.6	1.2
200	2.1	1.3	1.2
100	3.5	1.9	1.7
50	2	-0.2	-2.1
Mean	1.6	0.9	0.2

TROPICS

	T+24	T+72	T+120
850	0	0.5	0.5
700	4.4	1.3	-0.3
500	0.7	1.1	0.4
300	0.3	0	0
250	1.1	-1	-1
200	-0.3	-1.4	-1.1
100	-4.8	-3.4	-1.5
50	-2.4	-3.3	-2.3
Mean	-0.1	-0.8	-0.7

SH

	T+24	T+72	T+120
850	0.6	-1.8	0.9
700	0.5	-1.4	0.5
500	2	-0.1	1.1
300	0.2	-0.2	-0.5
250	0.5	-0.3	0.8
200	1	-0.3	-0.5
100	0.6	0.4	1.2
50	0.3	0.9	1.5
Mean	0.7	-0.4	0.6

TABLE B.8

Verification against analyses
Period= 19/02/96-08/03/96

Relative humidity
AREA 2

	T+24	T+72	T+120
950	0.1	1	-0.3
850	-1	1.6	0.6
700	1.4	1.2	-0.5
500	0	1.2	0.4
Mean	0.1	1.3	0.1

NH

	T+24	T+72	T+120
950	-0.5	0.1	-0.8
850	0.3	0.4	0.1
700	0.9	0.1	-0.7
500	0.2	1.1	-0.3
Mean	0.2	0.4	-0.4

TROPICS

	T+24	T+72	T+120
950	0.2	-0.1	0.2
850	0	-1	-1.4
700	1.1	0.1	-0.8
500	1.5	0.6	0.2
Mean	0.7	-0.1	-0.5

SH

	T+24	T+72	T+120
950	1.4	-0.4	0.5
850	2.3	-0.2	-0.2
700	3.2	-0.1	-0.7
500	2.9	0	-0.2
Mean	2.5	-0.2	-0.2

TABLE B.9

Verification against analyses
Period= 19/02/96-08/03/96

Wind
AREA 2

	T+24	T+72	T+120
850	1.8	2.3	1.5
700	1.9	2.6	1.4
300	1.8	2	0.9
250	1.7	1.8	0.9
200	2.8	1.5	0.1
100	1.6	1.6	-1.7
Mean	1.9	2.0	0.5

NH

	T+24	T+72	T+120
850	1.7	0.8	0.1
700	2.2	0.7	-0.1
300	2	1.1	-0.3
250	1.9	1.2	-0.1
200	1.4	0.8	0.4
100	2.4	2.2	-0.4
Mean	1.9	1.1	-0.1

TROPICS

	T+24	T+72	T+120
850	-1.5	0.3	0.1
700	1.7	0.6	-0.1
300	2.8	1	1.5
250	1.8	0.8	0.6
200	0.5	1.1	0.4
100	1	1.5	0.9
Mean	1.1	0.9	0.6

SH

	T+24	T+72	T+120
850	0.2	-1.6	-1
700	0.8	-1.3	-0.7
300	1.5	-0.3	0.2
250	1.3	0.1	0.1
200	1.8	0.4	0.2
100	2.2	0.1	0.1
Mean	1.3	-0.4	-0.2

TABLE B.10

Verification against analyses
Period= 19/02/96-08/03/96

PMSL
AREA 2

T+24	T+72	T+120
1	2.2	0.1

NH

T+24	T+72	T+120
0.8	1.2	0.2

TROPICS

T+24	T+72	T+120
-1.4	1.5	-0.2

SH

T+24	T+72	T+120
-0.4	-1.6	-0.9

10m Wind
AREA 2

T+24	T+72	T+120
1.7	2	0.9

NH

T+24	T+72	T+120
2.1	0.7	0.4

TROPICS

T+24	T+72	T+120
-0.8	-0.4	-0.2

SH

T+24	T+72	T+120
0.9	-1.5	-1

1.5m Temperature
AREA 2

T+24	T+72	T+120
0.6	1.7	-1.1

NH

T+24	T+72	T+120
1	0.9	-0.5

TROPICS

T+24	T+72	T+120
0.6	0	1.4

SH

T+24	T+72	T+120
2.4	-1.3	0.8

APPENDIX C SUMMARY OF RMS SCORES FROM T+150 MINUTE CUTOFF EXPERIMENT

Table C.1 Percentage change in RMS height scores verified against sondes. A negative change indicates that the trial is an improvement.

Table C.2 Percentage change in RMS temperature scores verified against sondes. A negative change indicates that the trial is an improvement.

Table C.3 Percentage change in RMS relative humidity scores verified against sondes. A negative change indicates that the trial is an improvement.

Table C.4 Percentage change in RMS VWE's verified against sondes. A negative change indicates that the trial is an improvement.

Table C.5 Percentage change in RMS scores verified against surface observations. A negative change indicates that the trial is an improvement.

Table C.6 Percentage change in RMS height scores verified against analyses. A negative change indicates that the trial is an improvement.

Table C.7 Percentage change in RMS temperature scores verified against analyses. A negative change indicates that the trial is an improvement.

Table C.8 Percentage change in RMS relative humidity scores verified against analyses. A negative change indicates that the trial is an improvement.

Table C.9 Percentage change in RMS VWE's verified against analyses. A negative change indicates that the trial is an improvement.

Table C.10 Percentage change in RMS scores for surface parameters verified against analyses. A negative change indicates that the trial is an improvement.

TABLE C.1

Verification against sondes
Period= 9/03/96-31/03/96

Height
AREA 2

	T+00	T+24	T+72	T+120
850.0	-0.2	0.7	1.8	1.9
700.0	-0.5	0.4	1.6	1.7
500.0	-1.0	0.6	1.6	1.3
300.0	-0.9	0.9	1.1	1.1
250.0	-0.5	0.8	0.9	0.9
200.0	-0.4	0.5	0.8	0.5
100.0	-0.6	0.4	0.6	-0.4
50.0	0.0	1.1	1.0	0.5
Mean	-0.5	0.7	1.2	0.9

NH

	T+00	T+24	T+72	T+120
850.0	0.4	0.8	1.8	1.4
700.0	0.6	0.9	1.8	1.5
500.0	0.0	0.4	1.9	1.2
300.0	0.3	0.6	1.6	0.9
250.0	0.3	0.5	1.4	0.7
200.0	0.3	0.3	1.2	0.0
100.0	0.5	0.5	0.3	-0.7
50.0	1.4	1.4	0.4	-0.2
Mean	0.5	0.7	1.3	0.6

TROPICS

	T+00	T+24	T+72	T+120
850.0	0.6	-1.2	0.6	1.4
700.0	0.6	-0.9	-0.6	0.9
500.0	0.6	-0.9	-0.7	0.0
300.0	0.2	-0.8	-0.7	-1.1
250.0	0.3	-0.9	-0.9	-1.1
200.0	0.6	-0.7	-1.1	-1.2
100.0	1.3	-0.1	-0.7	-0.8
50.0	1.9	-1.4	-1.3	-1.3
Mean	0.8	-0.9	-0.7	-0.4

SH

	T+00	T+24	T+72	T+120
850.0	-0.3	2.3	1.0	-0.6
700.0	-0.2	1.7	0.6	-0.8
500.0	-1.4	0.9	1.6	1.3
300.0	-1.0	0.7	0.3	3.4
250.0	-1.5	0.1	0.0	4.0
200.0	-0.5	0.2	0.5	3.9
100.0	0.6	0.1	0.7	4.0
50.0	0.9	-0.2	0.6	3.0
Mean	-0.4	0.7	0.7	2.3

TABLE C.2

Verification against sondes
Period= 9/03/96-31/03/96

Temperature
AREA 2

	T+00	T+24	T+72	T+120
850.0	-0.5	0.6	1.0	-0.2
700.0	-1.4	0.3	1.8	0.1
500.0	-1.2	-0.2	1.5	1.0
300.0	-1.1	0.3	0.1	-0.9
250.0	-1.1	-0.2	1.1	0.4
200.0	-0.5	0.0	1.2	0.3
100.0	0.6	0.3	1.5	2.5
50.0	-0.2	0.2	1.2	1.4
Mean	-0.7	0.2	1.2	0.6

NH

	T+00	T+24	T+72	T+120
850.0	0.2	1.2	1.1	-0.5
700.0	-0.3	0.6	1.4	-0.2
500.0	0.0	0.9	1.1	0.8
300.0	0.0	-0.2	0.0	-0.2
250.0	-0.5	-0.2	0.2	0.8
200.0	0.0	0.0	0.2	0.9
100.0	2.7	1.0	1.3	1.1
50.0	2.9	0.9	0.0	0.9
Mean	0.6	0.5	0.7	0.5

TROPICS

	T+00	T+24	T+72	T+120
850.0	4.8	0.9	0.4	0.7
700.0	3.1	0.5	-0.5	1.8
500.0	3.0	-0.3	0.3	-1.2
300.0	2.1	1.1	0.3	0.4
250.0	1.5	0.2	0.0	-0.7
200.0	5.6	0.7	-1.2	-1.1
100.0	0.6	-0.2	1.2	0.1
50.0	-0.3	-1.0	-0.5	-0.1
Mean	2.6	0.2	0.0	-0.0

SH

	T+00	T+24	T+72	T+120
850.0	1.0	1.3	0.6	1.7
700.0	0.0	1.4	-0.2	1.7
500.0	0.0	0.5	0.6	4.3
300.0	-1.7	-0.2	-1.2	2.4
250.0	-0.5	0.0	2.0	1.3
200.0	0.7	-0.1	1.0	2.3
100.0	-0.2	0.8	0.3	2.5
50.0	-0.5	-0.7	-0.1	-0.8
Mean	-0.2	0.4	0.4	1.9

TABLE C.3

Verification against sondes
Period= 9/03/96-31/03/96

Relative humidity
AREA 2

	T+00	T+24	T+72	T+120
850.0	0.0	1.0	0.3	0.4
700.0	0.1	0.5	1.3	0.1
500.0	0.0	0.4	1.2	1.5
Mean	0.0	0.6	0.9	0.7

NH

	T+00	T+24	T+72	T+120
850.0	0.2	0.4	0.4	0.4
700.0	0.2	0.7	0.7	0.1
500.0	0.8	0.6	0.6	-0.3
Mean	0.4	0.6	0.6	0.1

TROPICS

	T+00	T+24	T+72	T+120
850.0	3.4	0.4	-0.4	-0.2
700.0	6.8	1.1	-0.3	0.5
500.0	12.9	0.8	0.5	-0.3
Mean	7.7	0.8	-0.1	0.0

SH

	T+00	T+24	T+72	T+120
850.0	1.8	0.8	-0.1	0.4
700.0	2.4	1.3	-0.5	2.1
500.0	7.8	1.1	-0.9	-0.1
Mean	4.0	1.1	-0.5	0.8

TABLE C.4

Verification against sondes
Period= 9/03/96-31/03/96

Wind
AREA 2

	T+00	T+24	T+72	T+120
850.0	0.0	0.5	0.8	0.4
700.0	-0.3	0.5	0.8	1.4
300.0	-0.7	0.6	0.8	-0.5
250.0	-0.7	0.1	0.5	0.2
200.0	-0.5	-0.5	0.4	0.3
100.0	0.6	-0.6	1.0	1.3
Mean	-0.3	0.1	0.7	0.5

NH

	T+00	T+24	T+72	T+120
850.0	0.3	0.5	0.5	0.7
700.0	0.3	0.7	0.5	0.4
300.0	0.1	0.8	0.7	-0.1
250.0	0.3	0.4	0.1	0.0
200.0	0.3	0.0	0.7	0.0
100.0	1.5	0.0	0.9	1.5
Mean	0.5	0.4	0.6	0.4

TROPICS

	T+00	T+24	T+72	T+120
850.0	2.5	-0.1	-0.2	-0.5
700.0	2.4	0.3	0.5	0.1
300.0	4.9	0.7	0.3	0.7
250.0	3.7	0.1	0.0	-0.1
200.0	6.2	0.7	0.4	-0.2
100.0	2.2	-0.1	0.3	-0.4
Mean	3.7	0.3	0.2	-0.1

SH

	T+00	T+24	T+72	T+120
850.0	2.6	1.0	0.3	0.6
700.0	2.4	0.0	0.6	1.5
300.0	2.2	0.6	-0.1	-0.1
250.0	3.5	0.2	0.8	0.3
200.0	1.0	-0.3	0.6	0.7
100.0	0.4	-0.3	1.1	-0.3
Mean	2.0	0.2	0.6	0.5

TABLE C.5

Verification against sondes
Period= 9/03/96-31/03/96

PMSL
AREA 2 2

T+00	T+24	T+72	T+120
0.2	1.1	1.1	1.5

NH

T+00	T+24	T+72	T+120
0.3	0.7	1.3	0.9

TROPICS

T+00	T+24	T+72	T+120
0.1	-1.2	0.1	0.8

SH

T+00	T+24	T+72	T+120
1.5	1.2	2	0.7

1.5m Temperature
AREA 2

T+00	T+24	T+72	T+120
-2.2	-1.5	-1.9	-0.3

NH

T+00	T+24	T+72	T+120
1	0.8	0.1	0.3

TROPICS

T+00	T+24	T+72	T+120
-0.6	0.7	0.3	1.2

SH

T+00	T+24	T+72	T+120
1	0.9	-0.2	-0.6

10m Wind
AREA 2

T+00	T+24	T+72	T+120
0	0.1	0.6	0.6

NH

T+00	T+24	T+72	T+120
0.1	0.1	-0.3	0.2

TROPICS

T+00	T+24	T+72	T+120
0	-0.2	0.2	0.2

SH

T+00	T+24	T+72	T+120
-0.1	0.2	1.1	0.8

TABLE C.6

Verification against analyses
Period= 9/03/96-31/03/96

Height
AREA 2

	T+24	T+72	T+120
850	0.2	1	0.4
700	0.2	1.1	0.2
500	0.5	1	-0.3
300	0.8	0.7	-0.7
250	0.9	0.7	-0.9
200	0.7	1	-1
100	-0.3	1.9	1.3
50	1.6	1.3	1.1
Mean	0.6	1.1	0.0

NH

	T+24	T+72	T+120
850	0.7	1.9	1.1
700	0.6	2	1.2
500	0.5	1.9	1
300	1.1	1.5	0.9
250	1.3	1.4	0.8
200	1.2	1.4	0.7
100	0.5	1	1
50	0.2	-0.3	0.3
Mean	0.8	1.4	0.9

TROPICS

	T+24	T+72	T+120
850	-1.4	-2.8	-1.3
700	-2.5	-3.9	-1.4
500	-2.8	-4.3	-1.7
300	-2.8	-3.7	-2.5
250	-2.1	-2.7	-2.5
200	-1.9	-2.7	-2.8
100	-1.5	-1.8	-2.1
50	-5.2	-2.1	-1.1
Mean	-2.5	-3.0	-1.9

SH

	T+24	T+72	T+120
850	-1.2	0.2	1.6
700	-1.2	0	1.5
500	-0.5	0	1.3
300	0	0.1	1.2
250	-0.2	0.1	1.1
200	-0.4	0.1	0.9
100	-0.6	0.4	1.4
50	-0.2	0.8	1.9
Mean	-0.5	0.2	1.4

TABLE C.7

Verification against analyses
Period= 9/03/96-31/03/96

Temperature
AREA 2

	T+24	T+72	T+120
850	1.4	0.7	-0.3
700	1.2	-0.3	-1
500	1	0.3	-0.2
300	0.2	0.2	-0.6
250	0.2	0.5	1
200	0.2	0	0.2
100	2.7	0.6	-0.1
50	1.9	0.6	-0.3
Mean	1.1	0.3	-0.2

NH

	T+24	T+72	T+120
850	0.9	1.1	0.5
700	1.3	0.9	0.4
500	1.7	1.2	1
300	0.8	0.7	0.1
250	1	1.2	0.7
200	1.5	0.3	1.2
100	3.5	1.8	0.9
50	1.8	0.4	0.2
Mean	1.6	1.0	0.6

TROPICS

	T+24	T+72	T+120
850	1.6	0	-0.3
700	1.7	0.9	0
500	1.8	0.6	-0.3
300	1.8	-0.4	-1.9
250	0.9	-1.5	-1.2
200	-0.4	-2.3	-2.8
100	0	1.6	0.1
50	-4.1	-1.3	0.6
Mean	0.4	-0.3	-0.7

SH

	T+24	T+72	T+120
850	0	0.2	0.3
700	1.2	-0.3	0.2
500	0.3	0.1	0.3
300	0.3	0.1	0.9
250	0	0	1.2
200	0.3	-0.2	0.3
100	0	0	0.4
50	-1	0.5	0.8
Mean	0.1	0.1	0.6

TABLE C.8

Verification against analyses
Period= 9/03/96-31/03/96

Relative humidity
AREA 2

	T+24	T+72	T+120
950	0.5	0.4	0.5
850	1	0.3	0.7
700	1.6	0.9	0.2
500	0.8	0.6	0.7
Mean	1.0	0.6	0.5

NH

	T+24	T+72	T+120
950	0.9	0.8	0.2
850	1.3	0.8	0.4
700	1.5	1	0.4
500	1.3	0.8	0.2
Mean	1.3	0.9	0.3

TROPICS

	T+24	T+72	T+120
950	-0.1	-0.2	-0.1
850	-0.6	-0.1	-0.9
700	0.2	0.1	-0.6
500	1.7	0.8	0.3
Mean	0.3	0.2	-0.3

SH

	T+24	T+72	T+120
950	1.2	-0.7	-0.1
850	1.7	0.1	-0.2
700	2	0.2	-0.4
500	1.4	0.1	0
Mean	1.6	-0.1	-0.2

TABLE C.9

Verification against analyses
Period= 9/03/96-31/03/96

Wind
AREA 2

		T+24	T+72	T+120
	850	1	0.4	0.2
	700	1.1	0.6	0.6
	300	1.5	0.9	0.1
	250	1.4	0.7	0
	200	0.9	0.7	-0.3
	100	-0.1	1.4	0.7
Mean		1.0	0.8	0.2

NH

		T+24	T+72	T+120
	850	1.1	0.9	0.8
	700	0.9	1.1	0.8
	300	1.5	1.1	0.6
	250	1.3	0.6	0.7
	200	1.1	0.8	0.5
	100	0.5	1	0.5
Mean		1.1	0.9	0.7

TROPICS

		T+24	T+72	T+120
	850	-0.3	0.5	0
	700	1	0.6	0.2
	300	0.9	0.7	-0.3
	250	1.5	0.9	0.3
	200	1.9	0.8	0.1
	100	-0.8	1.3	-0.9
Mean		0.7	0.8	-0.1

SH

		T+24	T+72	T+120
	850	0.2	-0.3	0.6
	700	0.2	-0.4	0.5
	300	0.5	-0.1	-0.1
	250	0.6	0	-0.1
	200	0.8	0.2	0
	100	0.5	0.5	0.5
Mean		0.5	-0.0	0.2

TABLE C.10

Verification against analyses
Period= 9/03/96-31/03/96

PMSL
AREA 2

T+24	T+72	T+120
0.1	1	0.2

NH

T+24	T+72	T+120
0.7	1.6	0.8

TROPICS

T+24	T+72	T+120
-0.2	-1.3	-1

SH

T+24	T+72	T+120
-1.1	0.2	1.6

10m Wind
AREA 2

T+24	T+72	T+120
0.8	0.9	0.4

NH

T+24	T+72	T+120
0.7	0.9	0.6

TROPICS

T+24	T+72	T+120
-0.4	-0.1	-0.3

SH

T+24	T+72	T+120
0.5	-0.1	0.6

1.5m Temperature
AREA 2

T+24	T+72	T+120
1.3	-0.1	-0.6

NH

T+24	T+72	T+120
1.5	0.3	0.5

TROPICS

T+24	T+72	T+120
-1	-1.3	-1.7

SH

T+24	T+72	T+120
-0.5	-0.8	-0.3

APPENDIX D

PARALLEL SUITE EXPERIMENT No.39

Tropical Cyclone Forecast Track Verification

1. Sponsor

Clive Wilson, NWP Division.

2. Description of Experiment

Bring forward global main run cut-off time. See below for precise details.

3. Duration and Forecast Specification

The total period of the experiment was from 20.02.96 to 31.03.96. From 20.02.96 to 07.03.96 the cut-off time was 120 minutes. From 08.03.96 to 31.03.96 the cut-off time was 150 minutes. The operational cut-off time is 185 minutes.

PS forecasts were run out to T+120 every 24 hours at 12Z.

4. Tropical Cyclone Forecast Verification

a) Differences in samples

The OS run DT 12Z 23.02.96 dissipated TC Edwige by T+72; the corresponding PS run did not.
The PS run DT 12Z 24.02.96 dissipated TC Edwige by T+48; the corresponding OS run did not.
The PS run DT 12Z 02.03.96 dissipated TC Flossy by T+48; the corresponding OS run did not.
The PS run DT 12Z 03.03.96 dissipated TC Flossy by T+24; the corresponding OS run did not.
The PS run DT 12Z 12.03.96 dissipated TC Ethel by T+24; the corresponding OS run did not.
PS forecast for 21.03.96 not available.
The PS run DT 12Z 24.02.96 dissipated TC Guylianne by T+24; the corresponding OS run did not.

b) Verification Statistics

Total number of storms which were active during the period : **8**

Homogeneous samples were used in the statistical comparison

Forecast Error comparison for whole globe

	T+0	T+24	T+48	T+72	T+96	T+120
No. verified	36	25	17	11	7	4
Operational DPE	61	184	392	746	668	860
Parallel Suite DPE	94	222	373	732	650	807
% increase	+54.1	+20.7	-4.8	-1.9	-2.7	-6.2

No. verified : The number of forecasts verified for each forecast time
DPE : Direct Positional Error in kilometres
% increase : Percentage increase in PS forecast error compared to OS

The overall percentage increase in PS analysis/forecast error : +23.2%

Forecast Error comparison for South-West Indian Basin

	T+0	T+24	T+48	T+72	T+96	T+120
No. verified	17	12	8	6	5	3
Operational DPE	50	152	385	692	553	626
Parallel Suite DPE	112	210	379	637	501	544
% increase	+124.0	+38.2	-1.6	-7.9	-9.4	-13.1

The overall percentage increase in PS analysis/forecast error : +47.5%

Forecast Error comparison for Australian Basin

	T+0	T+24	T+48	T+72	T+96	T+120
No. verified	19	13	9	5	2	1
Operational DPE	71	214	398	810	955	1563
Parallel Suite DPE	78	232	367	845	1022	1594
% increase	+9.9	+8.4	-7.8	+4.3	+7.0	+2.0

The overall percentage increase in PS analysis/forecast error : +5.4%

5. Comments

Compared to previous experiments which used an earlier cut-off time the results of this experiment show some wide variations at different forecast times. Analyses and T+24 forecasts were much worse with an earlier cut-off time. At T+48 and beyond, the statistics indicate that forecasts are better with an earlier cut-off time. However, examination of individual forecasts indicate that the 12Z 28.02.96 forecast for TC Flossy had a major impact on the overall statistics. With an earlier cut-off, the storm's speed of movement was much slower in this forecast and forecast errors were much smaller than operationally. It is undetermined whether the larger error in the operational forecast resulted from bogus or real observations. Without this one forecast the overall statistics are altered considerably. *Decreases* in forecast error in the parallel suite run of 1.9%, 2.7% and 6.2% at T+72, T+96 and T+120 become *increases* in forecast error of 1.9%, 3.2% and 7.5% when calculated without this one forecast.

The overall increase in analysis/forecast error in the parallel run was 23.2%. This was heavily weighted towards the analysis figures which were much worse in the parallel run. However, even excluding the analysis errors, the overall forecast errors were increased by 5.8% in the parallel run. This increases to 8.1% without the one anomalous case mentioned above. With an earlier cut-off time the model erroneously dissipated a storm earlier in the forecast on five occasions and maintained it longer than the operational forecast on just one occasion.

Details of the formulation of the UKMO TC verification Scheme can be found in *nwp Gazette* Vol.1, No.2, December 1994.

Julian Heming, FS9

FIGURE CAPTIONS

All section 2 charts refer to 19/02/96 - 31/03/96

Figure 2.1 top - Location of 12Z synops received after T+150 minutes. centre - Number of synops and time of receipt T+90 - T+200 minutes after 12Z for the Northern Hemisphere, Tropics and Southern Hemisphere. bottom - Accumulated total synops and time of receipt.

Figure 2.2 as figure 2.1 but for 12Z ships

Figure 2.3 as Figure 2.1 but for 12Z sondes

Figure 2.3a as Figure 2.1 but for 12Z AMDARS

Figure 2.4a as Figure 2.1 but for 12Z AMDARS

Figure 2.4b as Figure 2.1 but for 00Z AMDARS

Figure 2.5a as Figure 2.1 but for 12Z AIREPS

Figure 2.5b as Figure 2.1 but for 00Z AIREPS

Figure 2.6 as Figure 2.1 but for 12Z drifting buoys

Figure 2.7 as Figure 2.1 but for 12Z SATOBS

Figure 2.8a as Figure 2.1 but for 12Z SATEMS

Figure 2.8b as Figure 2.1 but for 00Z SATEMS

Figure 2.9 as Figure 2.1 but for moored buoys

Figure 3.1 The percentage change in the RMS VWE's in the T+120 minute trial at T+12, verified against radio sondes (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at $\pm 1\%$ and are generally regarded as the limit of practical significance.

Figure 3.2 The percentage change in the RMS VWE's in the T+120 minute trial at T+24, verified against radio sondes (solid line). The dotted line is the verification of T+30 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at $\pm 1\%$ and are generally regarded as the limit of practical significance.

Figure 3.3 The percentage change in the RMS VWE's in the T+120 minute trial at T+12,

verified against AIREPS (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.4 The percentage change in the RMS VWE's in the T+120 minute trial at T+24, verified against AIREPS (solid line). The dotted line is the verification of T+30 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.5 The percentage change in the RMS VWE's in the T+120 minute trial at T+12, verified against AMDARS (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.6 The percentage change in the RMS VWE's in the T+120 minute trial at T+24, verified against AMDARS (solid line). The dotted line is the verification of T+30 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.7 The percentage change in the RMS temperature errors in the T+120 minute trial at T+12, verified against radio sondes (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.8 The percentage change in the RMS temperature errors in the T+120 minute trial at T+24, verified against radio sondes (solid line). The dotted line is the verification of T+30 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.9 The percentage change in the area 2 RMS VWE's in the T+120 minute trial at T+00, T+24, T+48, T+72, T+96 and T+120; all are verified against radio sondes (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.10 The percentage change in the RMS VWE's in the T+120 minute trial at T+00 in area 2, NH, tropics and SH; all are verified against AIREPS (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.11 The percentage change in the RMS VWE's in the T+120 minute trial at T+24 in area 2, NH, tropics and SH; all are verified against AIREPS (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.12 The percentage change in the RMS VWE's in the T+150 minute trial at T+12, verified against radio sondes (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.13 The percentage change in the RMS temperature errors in the T+150 minute trial at T+12, verified against radio sondes (solid line). The dotted line is the verification of T+18 06Z forecast runs, verifying at the same times. This shows the maximum possible deterioration due to shortening the data cutoff. The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.14 The percentage change in the T+00 RMS VWE's in the T+150 minute trial for the tropics and SH; both are verified against radio sondes (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.15 The percentage change in the area 2 and NH RMS VWE's in the T+150 minute trial at T+24 and T+48; all are verified against analyses (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.16 The percentage change in the T+00 RMS VWE's in the T+150 minute trial verified against AMDARS (solid line). The vertical dotted lines are at ±1% and are generally regarded as the limit of practical significance.

Figure 3.17 The scores found verifying PMSL and 1.5m temperature over the full LAM area (area 888) and UK & Iceland (area 5). Verification is shown for three forecasts: the operational global model (full line); the T+120 minute cutoff trial forecast (dashed line) and; the operational LAM forecast (dotted line). The biases are in the left hand column and the RMS errors are in the right hand column.

Figure 4.1 a) 250hPa isotach analysis for 12Z 20/02/96 from parallel suite trial T+120 minute cut-off. b) 250hPa isotach analysis for 12Z 20/02/96 from operational suite c) 250hPa wind vector analysis differences (trial-oper) for 12Z 20/02/96.

Figure 4.2 a) Mean sea level pressure analysis for 12Z 05/03/96 from parallel suite T+120 cut-off. b) Mean sea level pressure analysis for 12Z 05/03/96 from operational suite. c) Mean sea level pressure analysis differences (trial-oper) for 12Z 05/03/96.

Figure 4.3 a)T+120 mean sea level pressure forecast vt 12Z 09/03/96 from parallel suite trial T+120 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 09/03/96 from

operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 09/03/96. d) Mean sea level pressure operational analysis for 12Z 09/03/96.

Figure 4.4 a) T+120 500hPa height forecast vt 12Z 09/03/96 from parallel suite trial T+120 cut-off. b) T+120 500hPa height forecast vt 12Z 09/03/96 from operational suite. c) T+120 500hPa height differences (trial-oper) for vt 12Z 09/03/96. d) 500hPa height operational analysis for 12Z 09/03/96.

Figure 4.5 a) T+120 mean sea level pressure forecast vt 12Z 03/03/96 from parallel suite trial T+120 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 03/03/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 03/03/96. d) Mean sea level pressure operational analysis for 12Z 03/03/96.

Figure 4.6 a) T+120 mean sea level pressure forecast vt 12Z 27/02/96 from parallel suite trial T+120 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 27/02/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 27/02/96. d) Mean sea level pressure operational analysis for 12Z 27/02/96.

Figure 4.7 a) T+120 500hPa height forecast vt 12Z 27/02/96 from parallel suite trial T+120 cut-off. b) T+120 500hPa height forecast vt 12Z 27/02/96 from operational suite. c) T+120 500hPa height differences (trial-oper) for vt 12Z 27/02/96. d) 500hPa height operational analysis for 12Z 27/02/96.

Figure 4.8 a) T+72 mean sea level pressure forecast vt 12Z 05/03/96 from parallel suite trial T+120 cut-off. b) T+72 mean sea level pressure forecast vt 12Z 05/03/96 from operational suite. c) T+72 mean sea level pressure differences (trial-oper) for vt 12Z 05/03/96. d) Mean sea level pressure operational analysis for 12Z 05/03/96.

Figure 4.9 a) T+24 forecast 250hPa wind isotachs vt 12Z 26/02/96 from parallel suite trial T+120 cut-off. b) T+24 forecast 250hPa wind isotachs vt 12Z 26/02/96 from operational suite. c) T+24 forecast 250hPa wind vector differences (trial -oper) vt 12Z 26/02/96. d) T+24 analysis 250hPa wind isotachs vt 12Z 26/02/96 from operational suite.

Figure 4.10 a) T+24 forecast 250hPa wind isotachs vt 12Z 04/03/96 from parallel suite trial T+120 cut-off. b) T+24 forecast 250hPa wind isotachs vt 12Z 04/03/96 from operational suite. c) T+24 forecast 250hPa wind vector differences (trial -oper) vt 12Z 04/03/96. d) T+24 analysis 250hPa wind isotachs vt 12Z 04/03/96 from operational suite.

Figure 4.11 a) Mean sea level pressure analysis for 12Z 08/03/96 from parallel suite T+150 cut-off. b) Mean sea level pressure analysis for 12Z 08/03/96 from operational suite. c) Mean sea level pressure analysis differences (trial-oper) for 12Z 08/03/96.

Figure 4.12 a) 250hPa isotach analysis for 12Z 08/03/96 from parallel suite trial T+150 minute cut-off. b) 250hPa isotach analysis for 12Z 08/03/96 from operational suite. c) 250hPa wind vector analysis differences (trial-oper) for 12Z 08/03/96.

Figure 4.13 a) T+120 mean sea level pressure forecast vt 12Z 18/03/96 from parallel suite trial T+150 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 18/03/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 18/03/96. d) Mean sea level pressure operational analysis for 12Z 18/03/96.

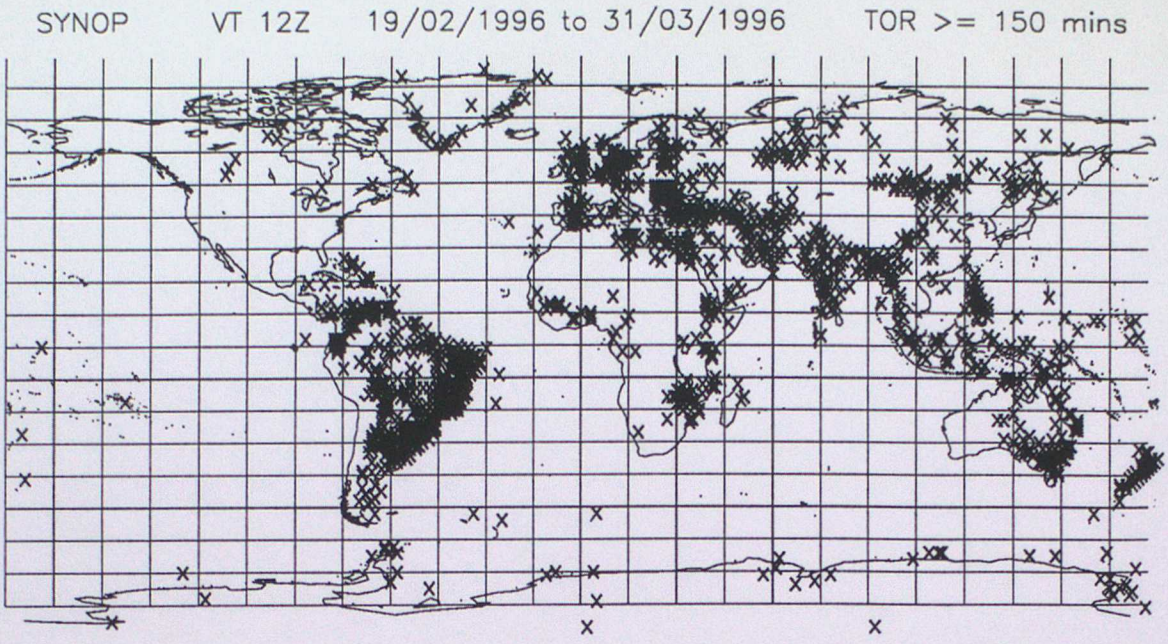
Figure 4.14 a) T+120 mean sea level pressure forecast vt 12Z 01/04/96 from parallel suite trial T+150 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 01/04/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 01/04/96. d) Mean sea level pressure operational analysis for 12Z 01/04/96.

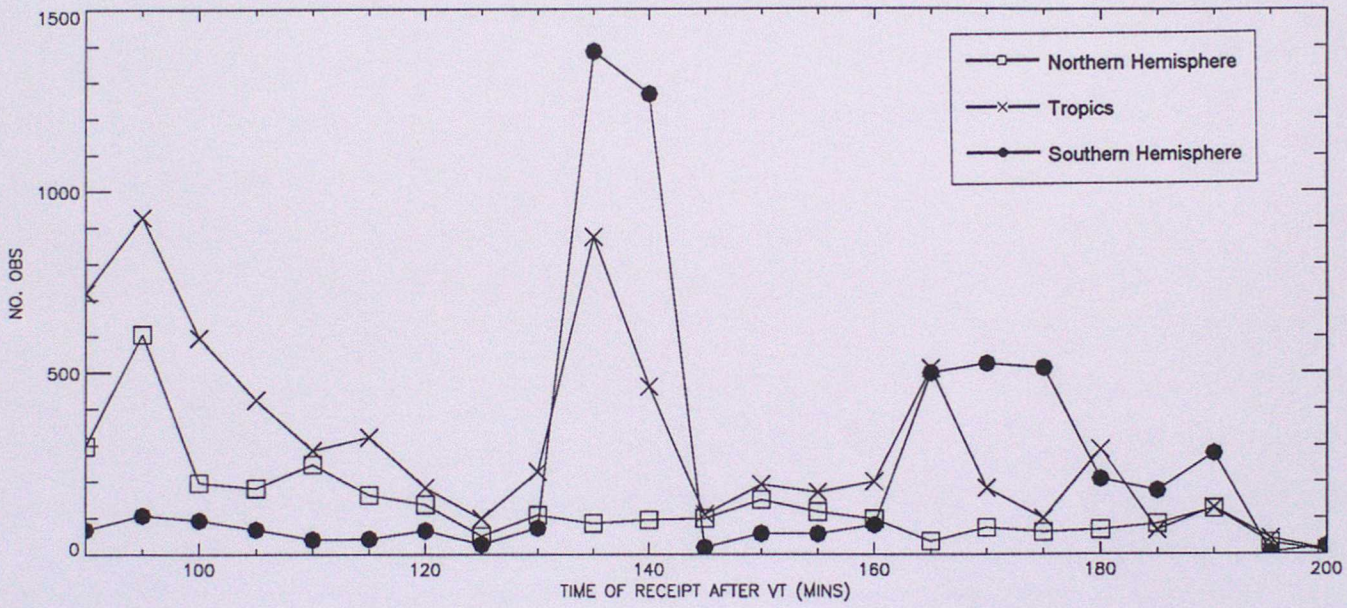
Figure 4.15 a) T+120 mean sea level pressure forecast vt 12Z 27/03/96 from parallel suite trial T+150 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 27/03/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 27/03/96. d) Mean sea level pressure operational analysis for 12Z 27/03/96.

Figure 4.16 a) T+120 mean sea level pressure forecast vt 12Z 16/03/96 from parallel suite trial T+150 cut-off. b) T+120 mean sea level pressure forecast vt 12Z 16/03/96 from operational suite. c) T+120 mean sea level pressure differences (trial-oper) for vt 12Z 16/03/96. d) Mean sea level pressure operational analysis for 12Z 16/03/96.

Figure 4.17 a) T+24 forecast 250hPa wind isotachs vt 12Z 24/03/96 from parallel suite trial T+150 cut-off. b) T+24 forecast 250hPa wind isotachs vt 12Z 24/03/96 from operational suite. c) T+24 forecast 250hPa wind vector differences (trial -oper) vt 12Z 24/03/96. d) T+24 analysis 250hPa wind isotachs vt 12Z 24/03/96 from operational suite.

Figure 4.18 a) T+24 forecast 250hPa wind isotachs vt 12Z 27/03/96 from parallel suite trial T+150 cut-off. b) T+24 forecast 250hPa wind isotachs vt 12Z 27/03/96 from operational suite. c) T+24 forecast 250hPa wind vector differences (trial -oper) vt 12Z 27/03/96. d) T+24 analysis 250hPa wind isotachs vt 12Z 27/03/96 from operational suite


SYNOP VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
1500
1000
500
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

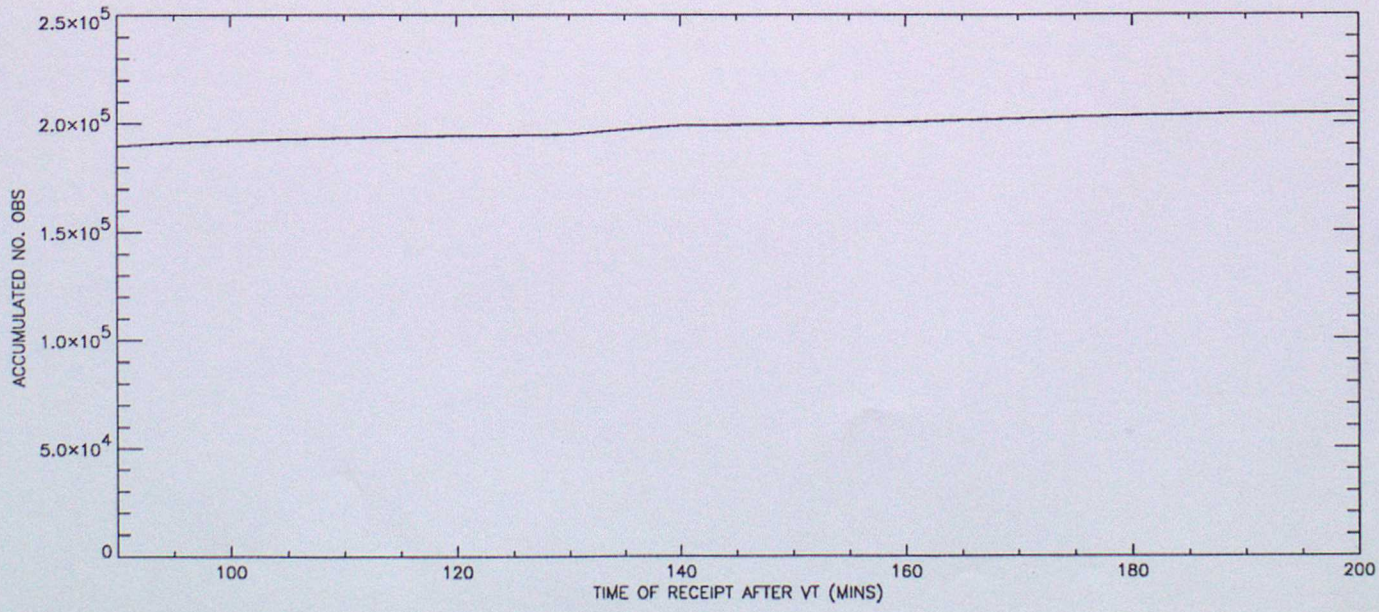
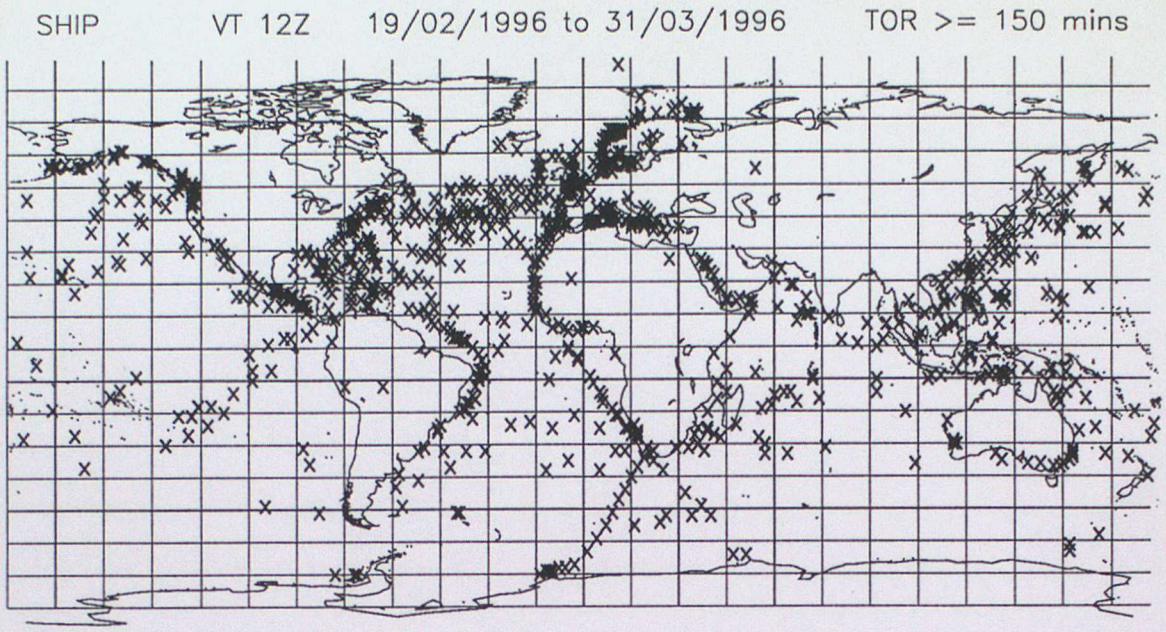
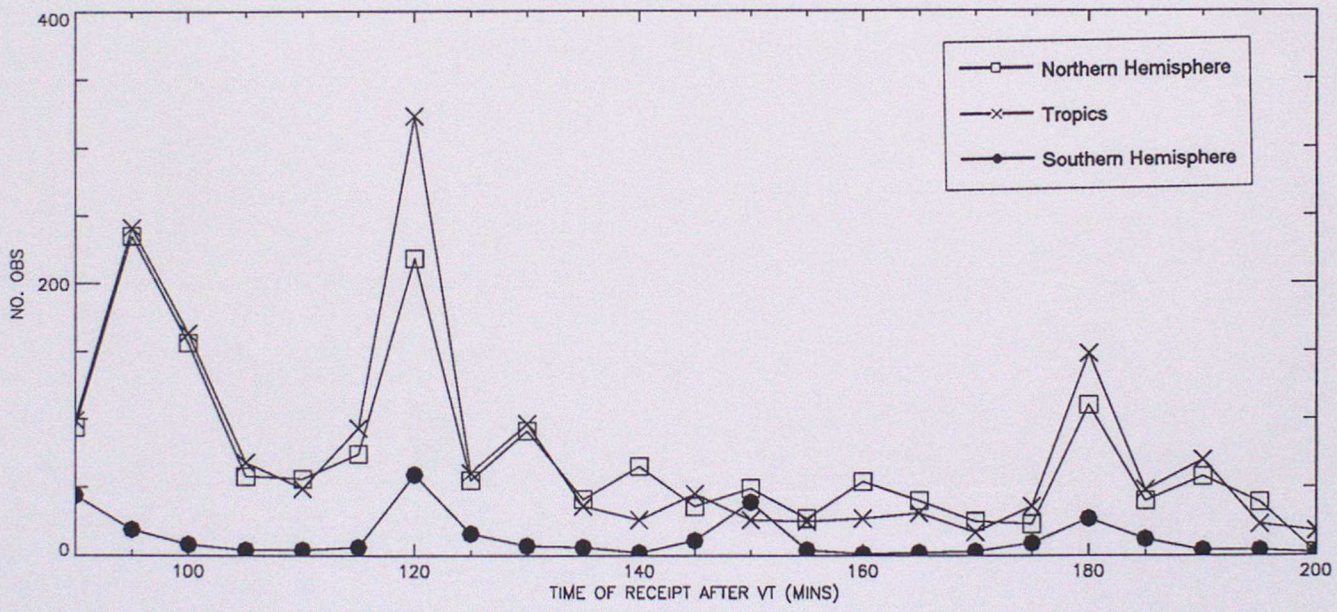

ACCUMULATED NO. OBS
2.5x10^5
2.0x10^5
1.5x10^5
1.0x10^5
5.0x10^4
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.1


SHIP
VT 12Z
19/02/1996 to 31/03/1996
TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
400
200
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

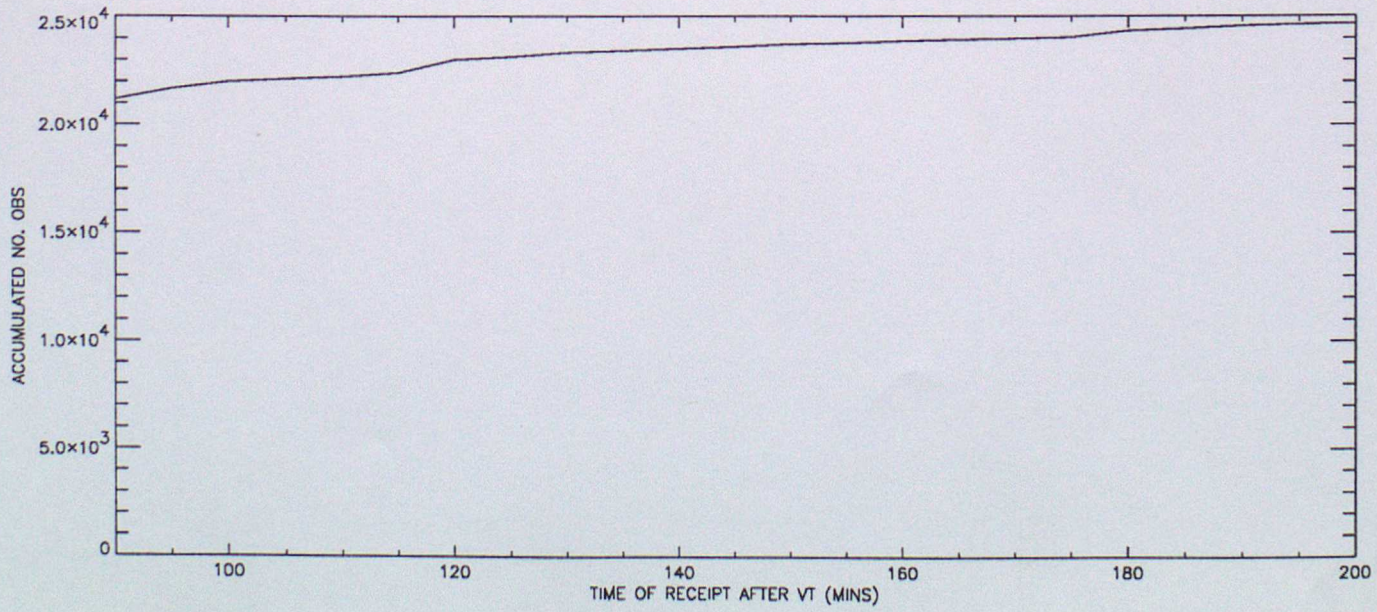
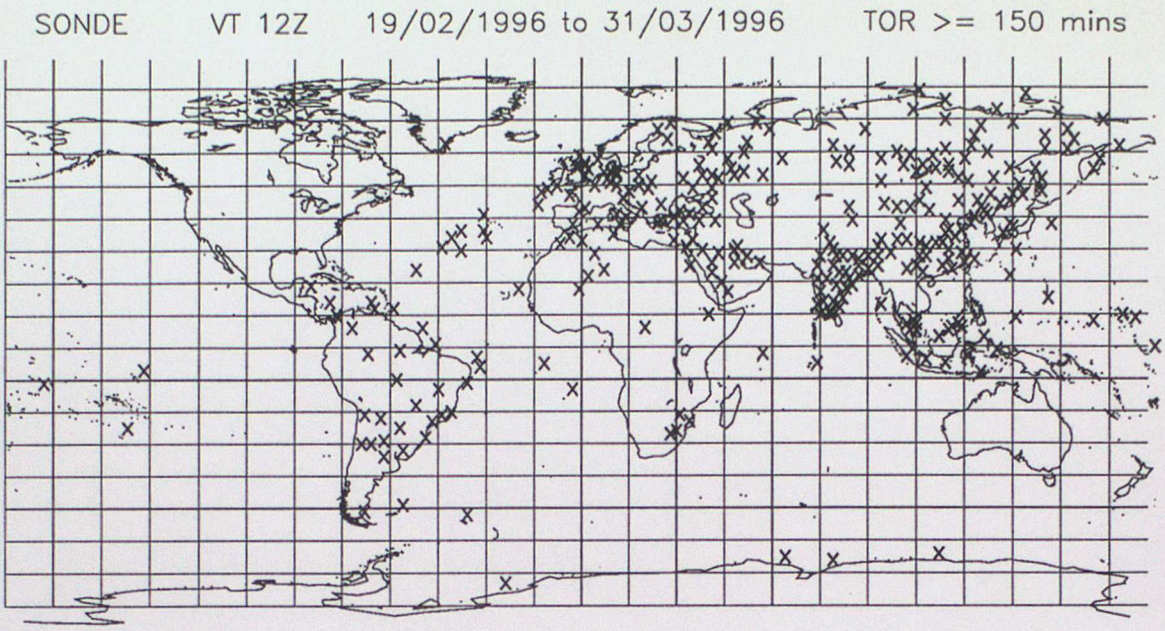
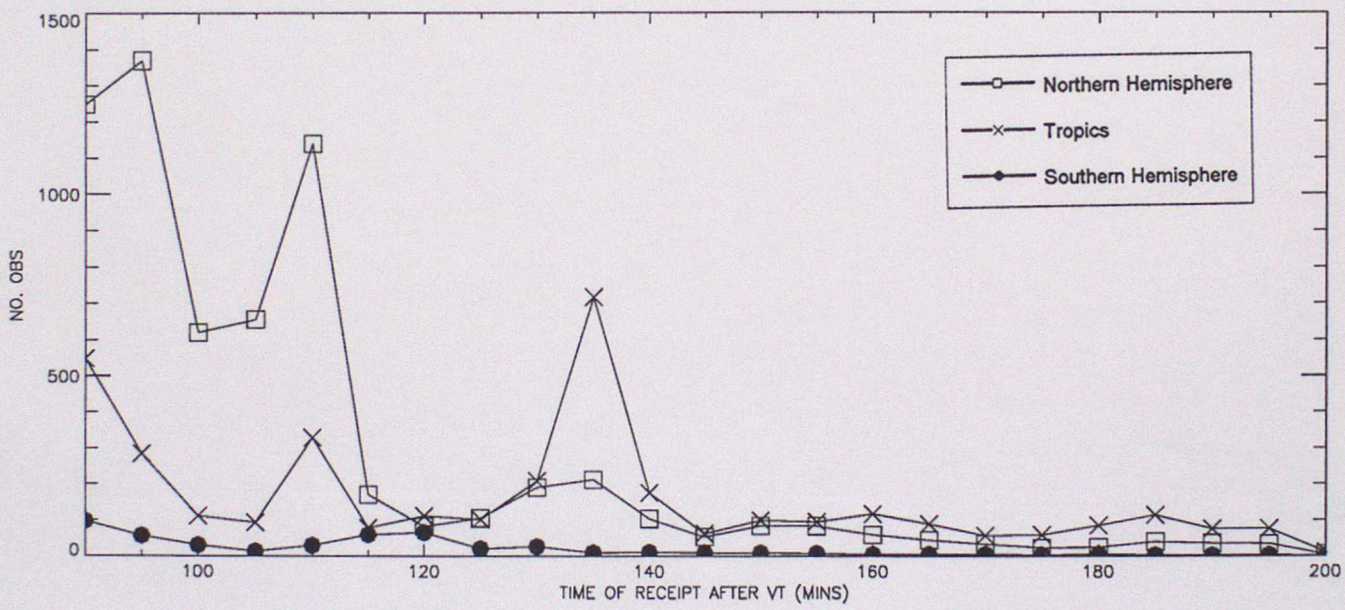

ACCUMULATED NO. OBS
2.5×10^4
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.2


SONDE VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


1500
1000
500
0
NO. OBS
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)
Northern Hemisphere
Tropics
Southern Hemisphere

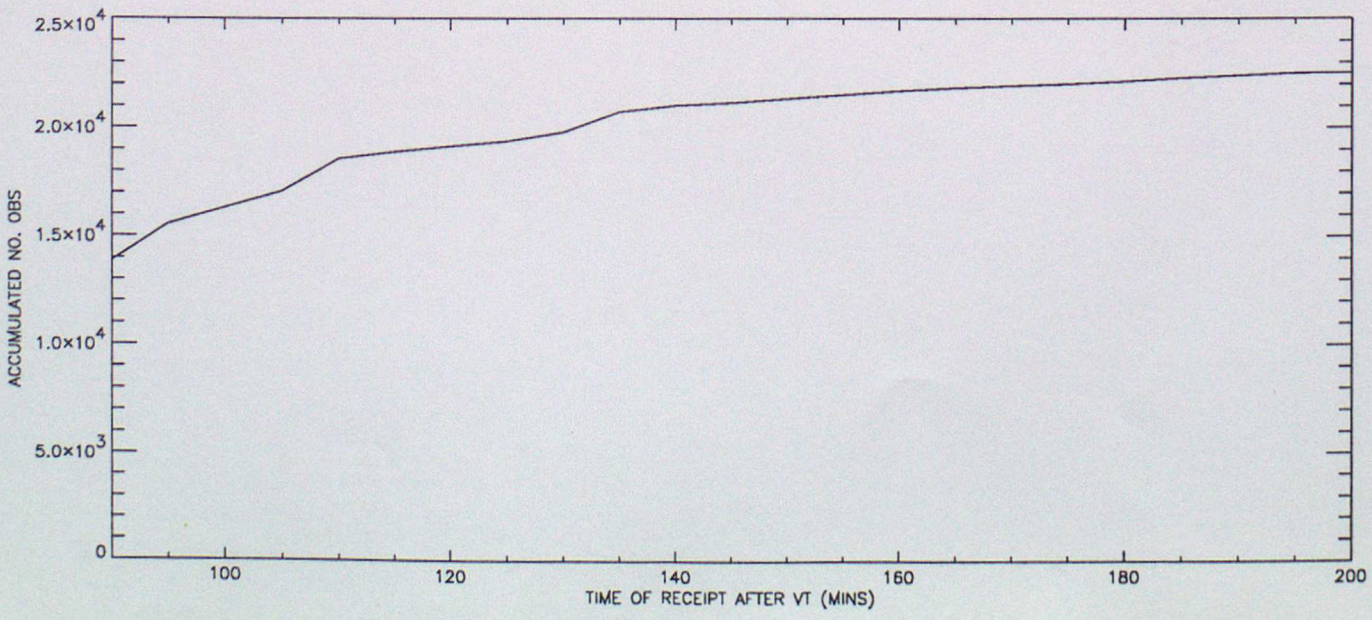

2.5x10^4
2.0x10^4
1.5x10^4
1.0x10^4
5.0x10^3
0
ACCUMULATED NO. OBS
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.3

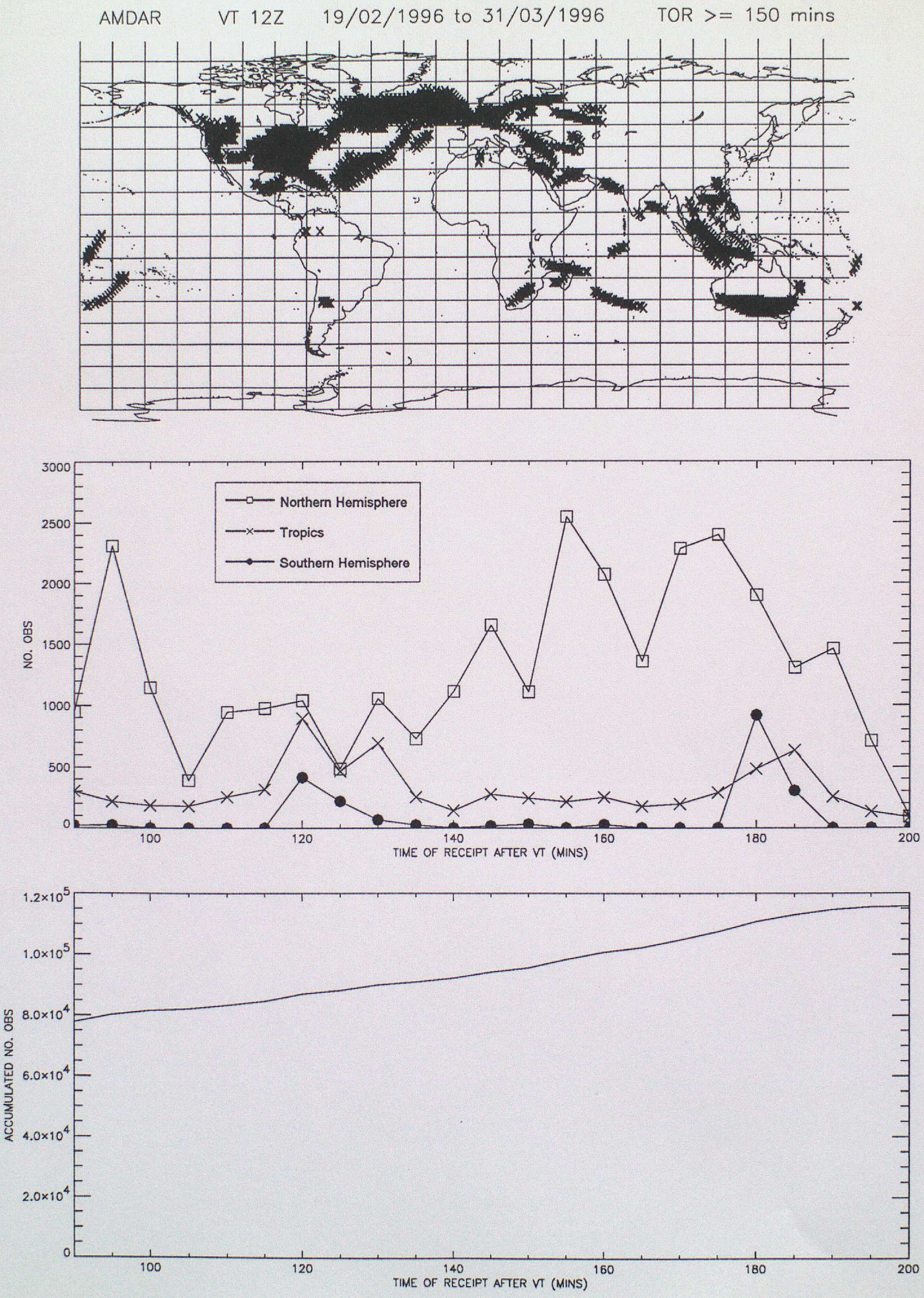
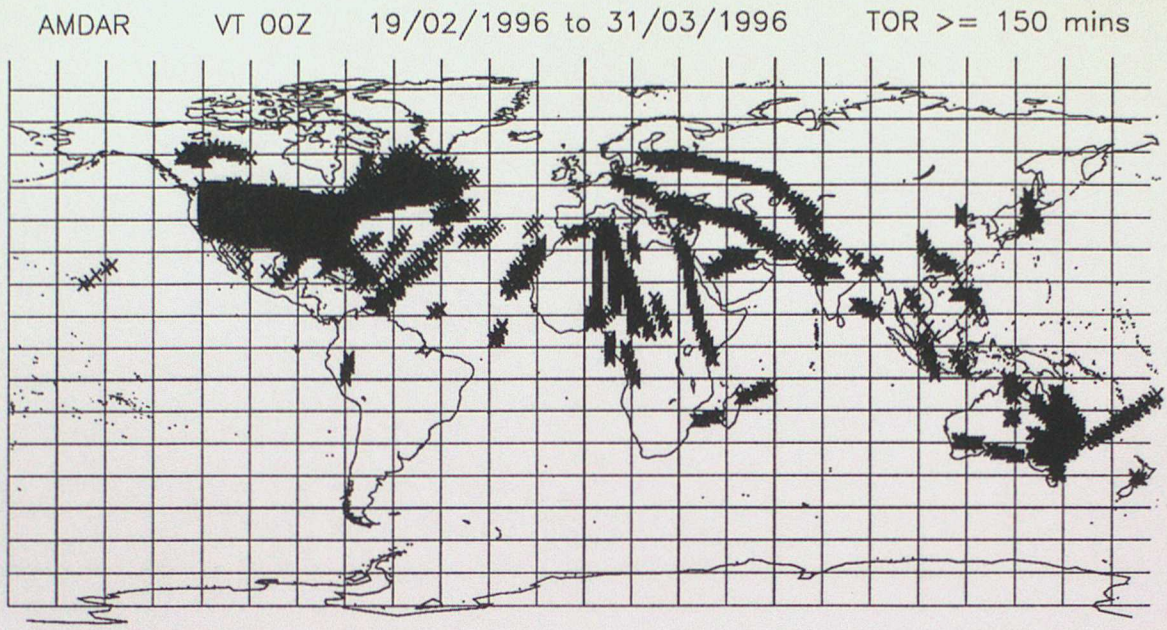
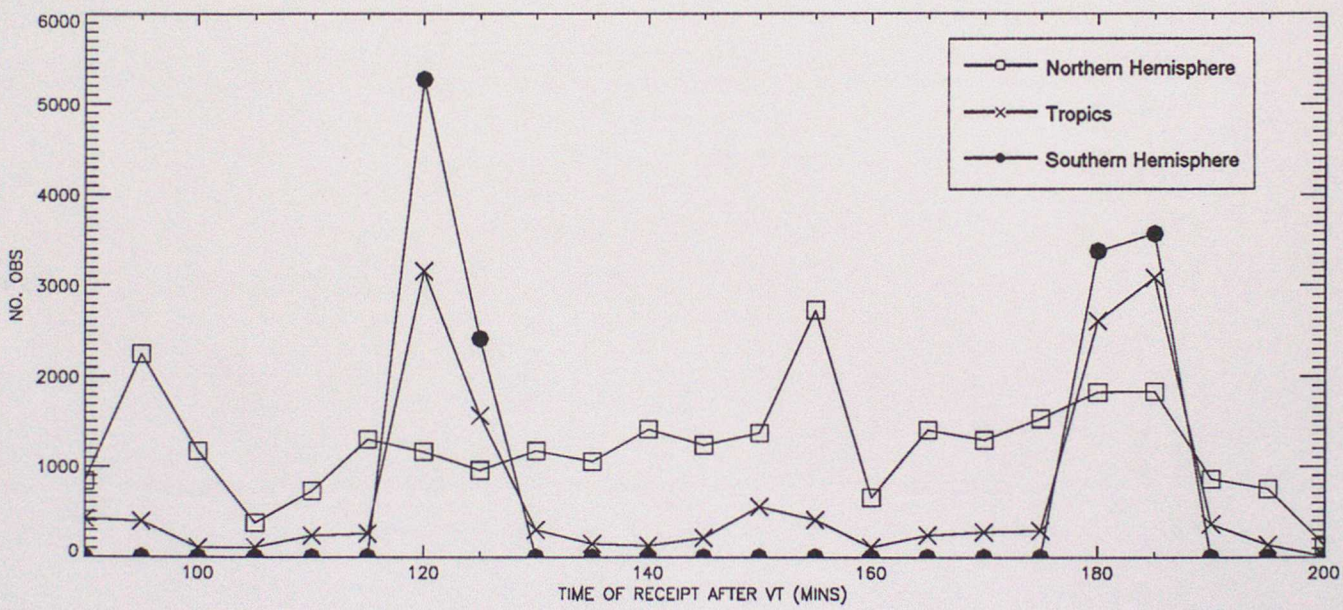

AMDAR VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins
Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)
ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.4a


AMDAR VT 00Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

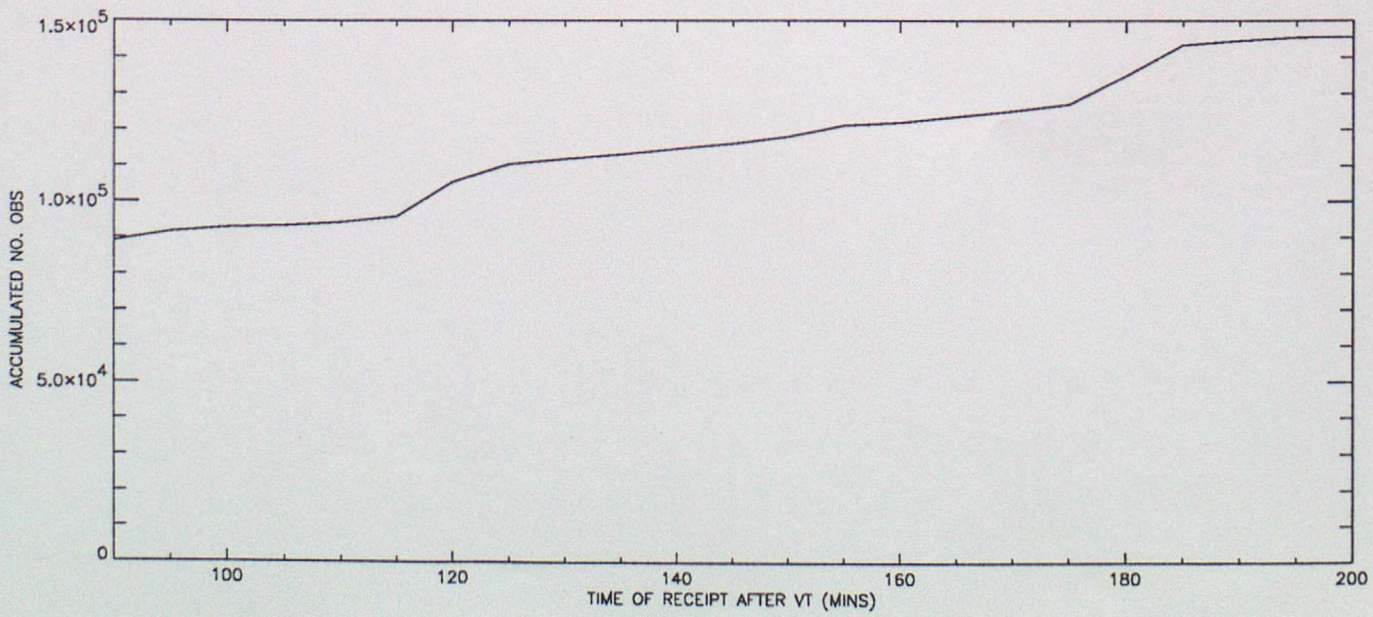
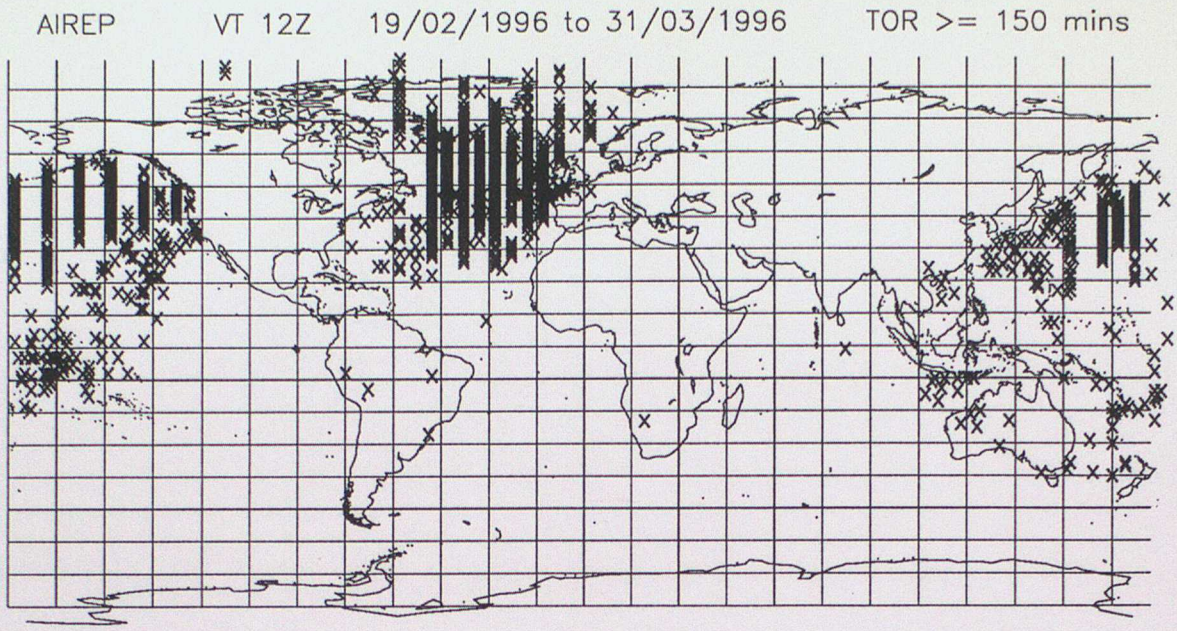
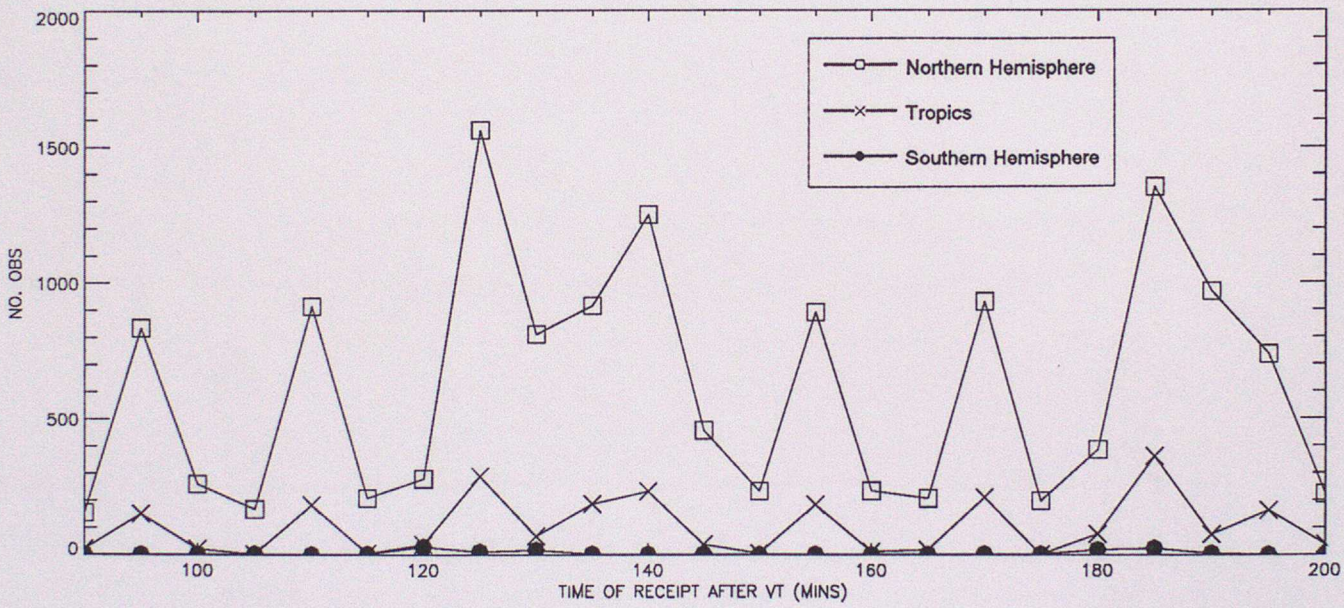

ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.4b


AIREP VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
2000
1500
1000
500
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

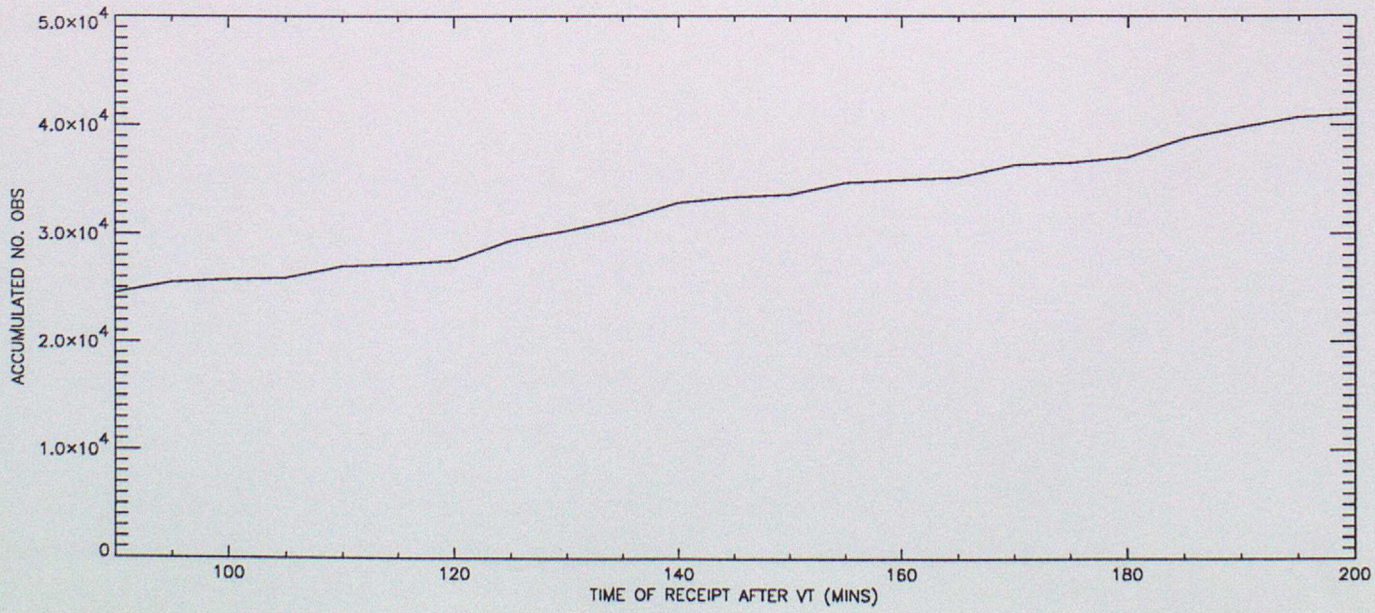
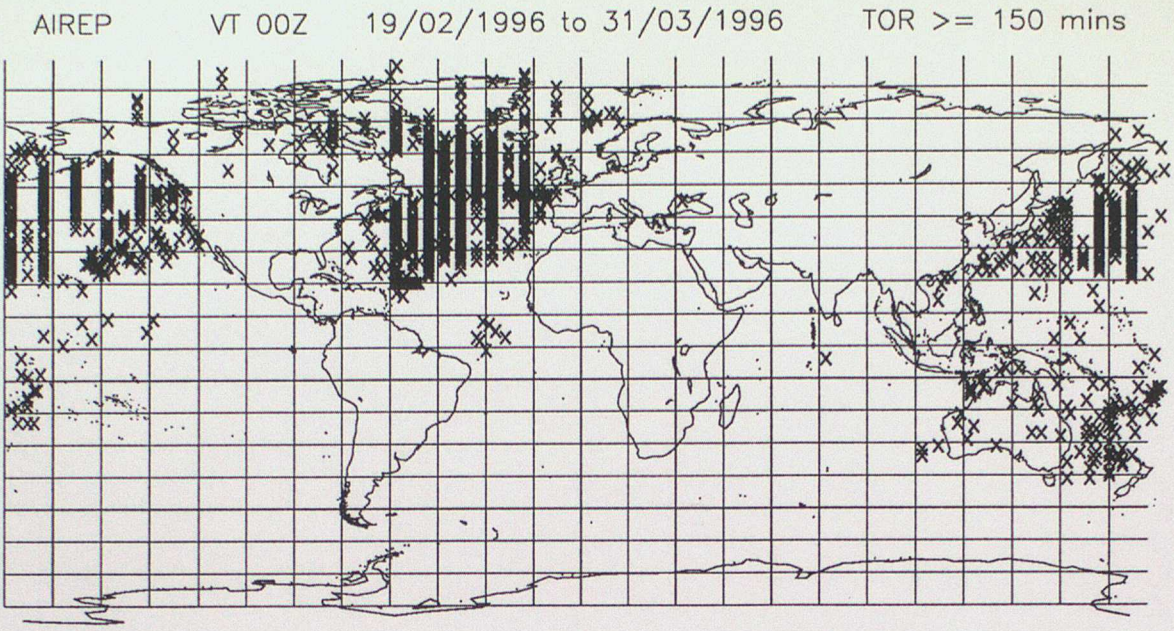
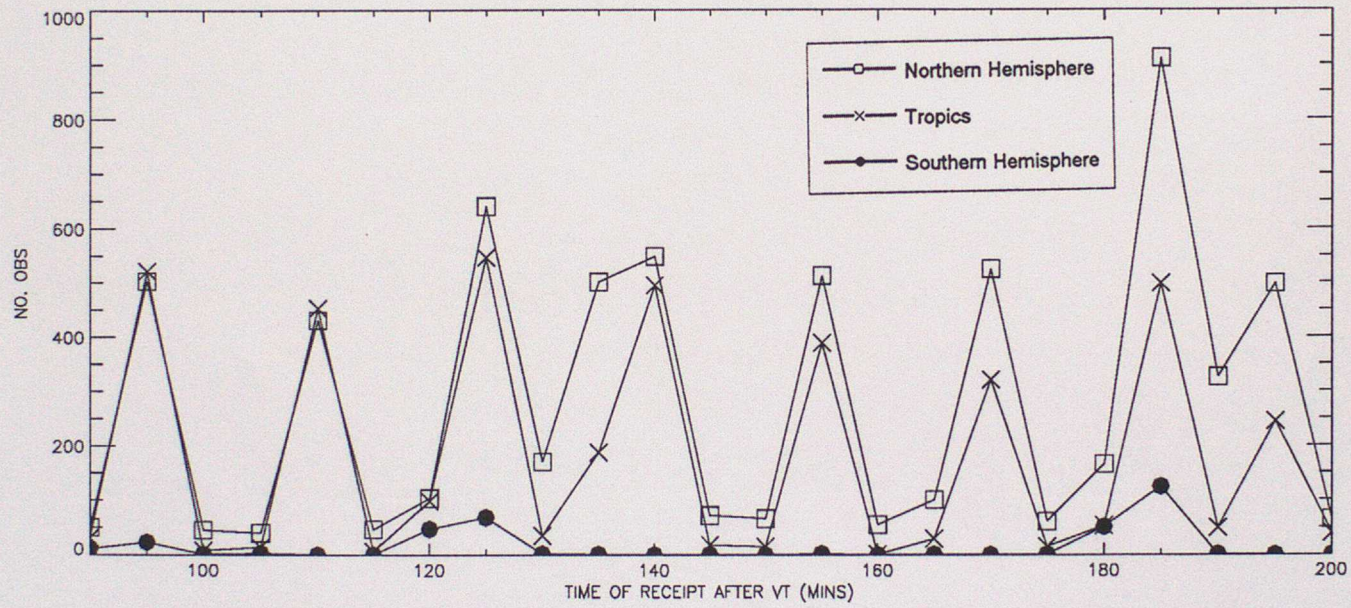

ACCUMULATED NO. OBS
5.0x10^4
4.0x10^4
3.0x10^4
2.0x10^4
1.0x10^4
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.5a


AIREP VT 00Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

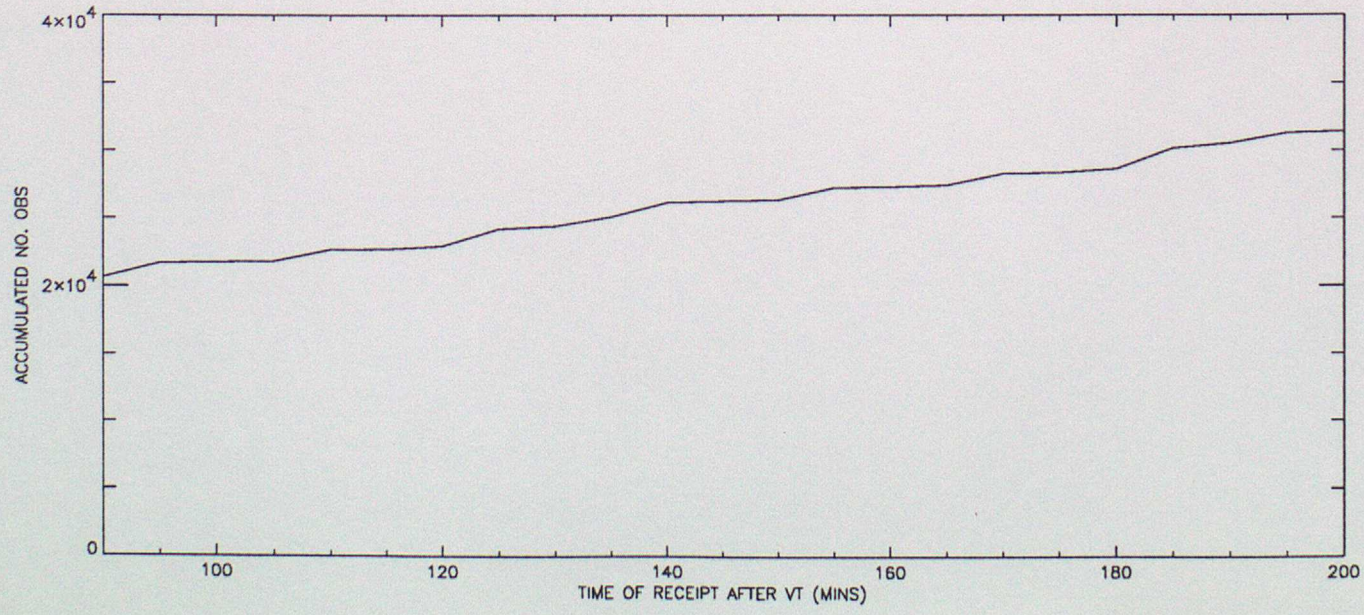
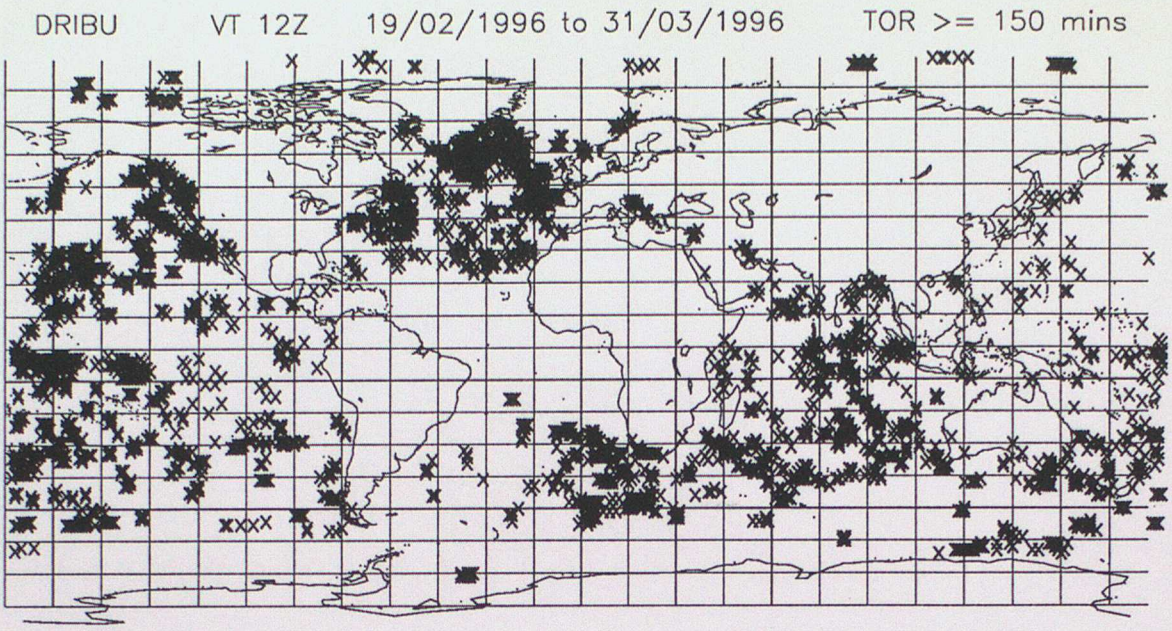
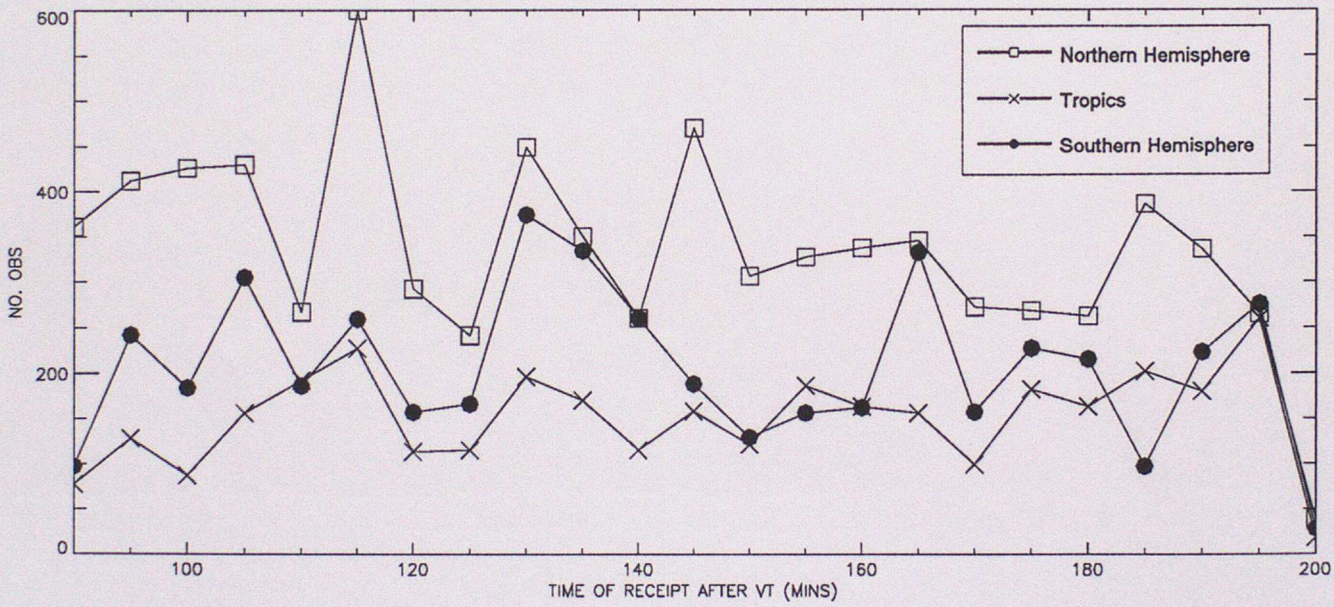

ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.5b


DRIBU VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

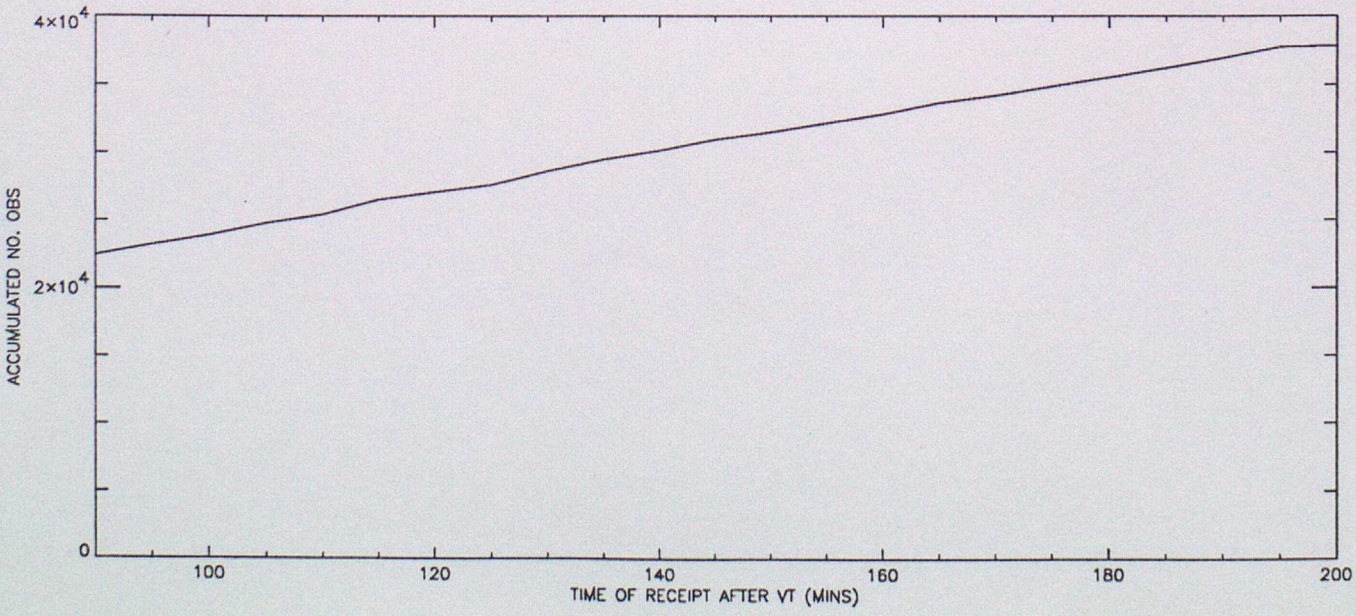
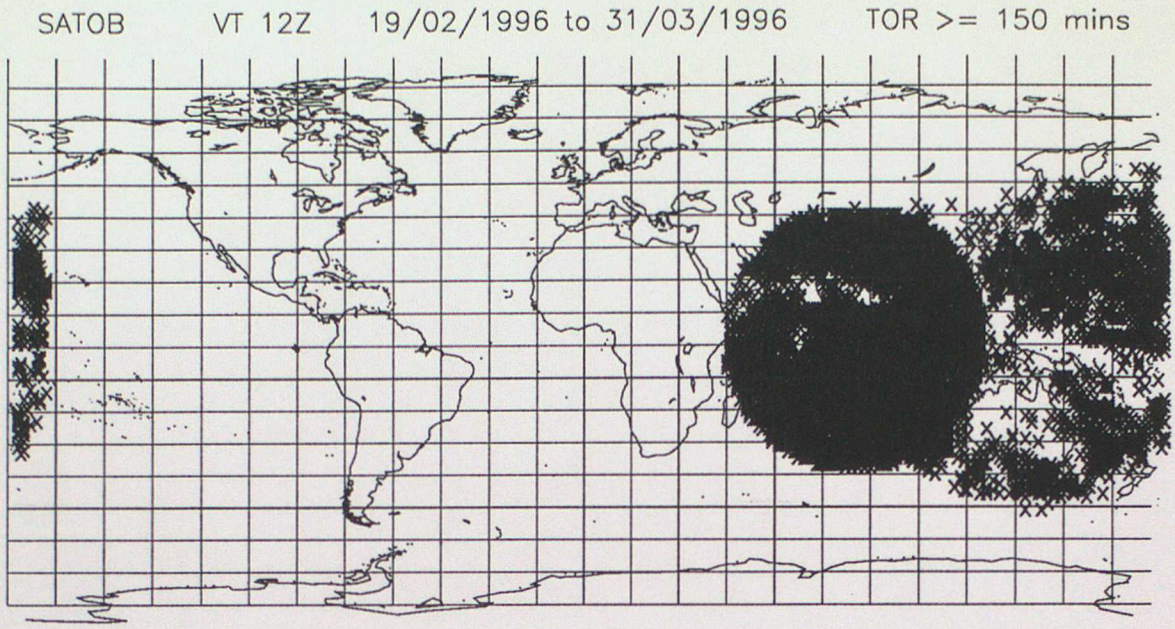
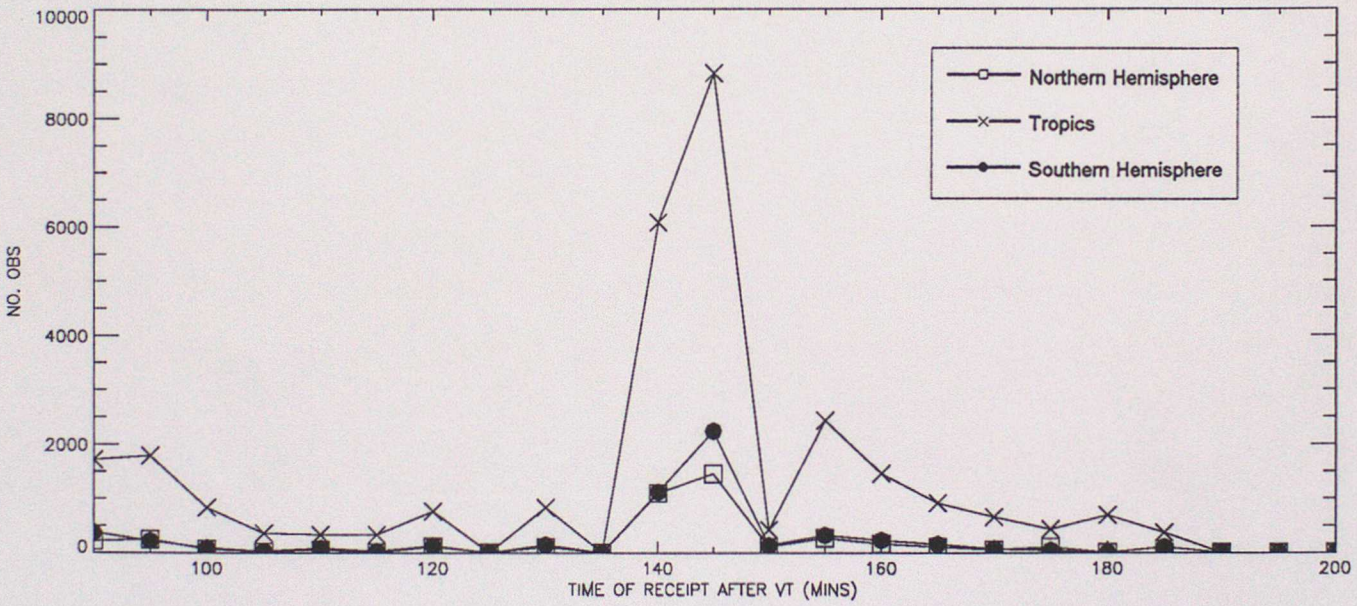

ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.6


SATOB VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

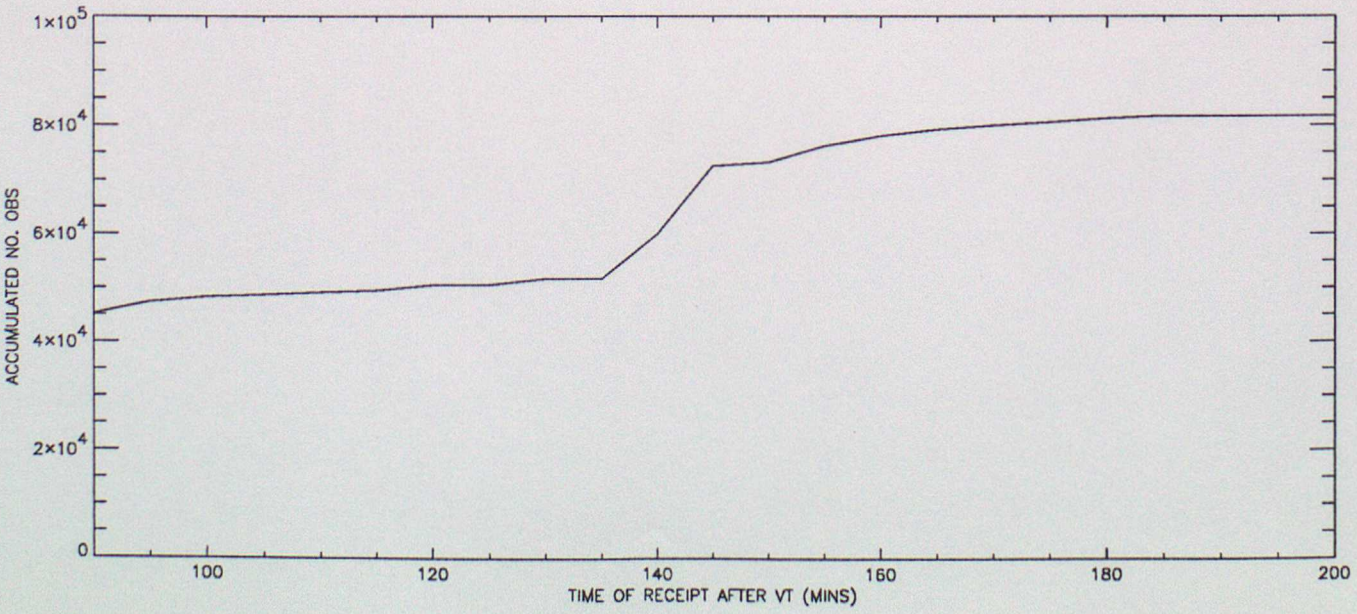
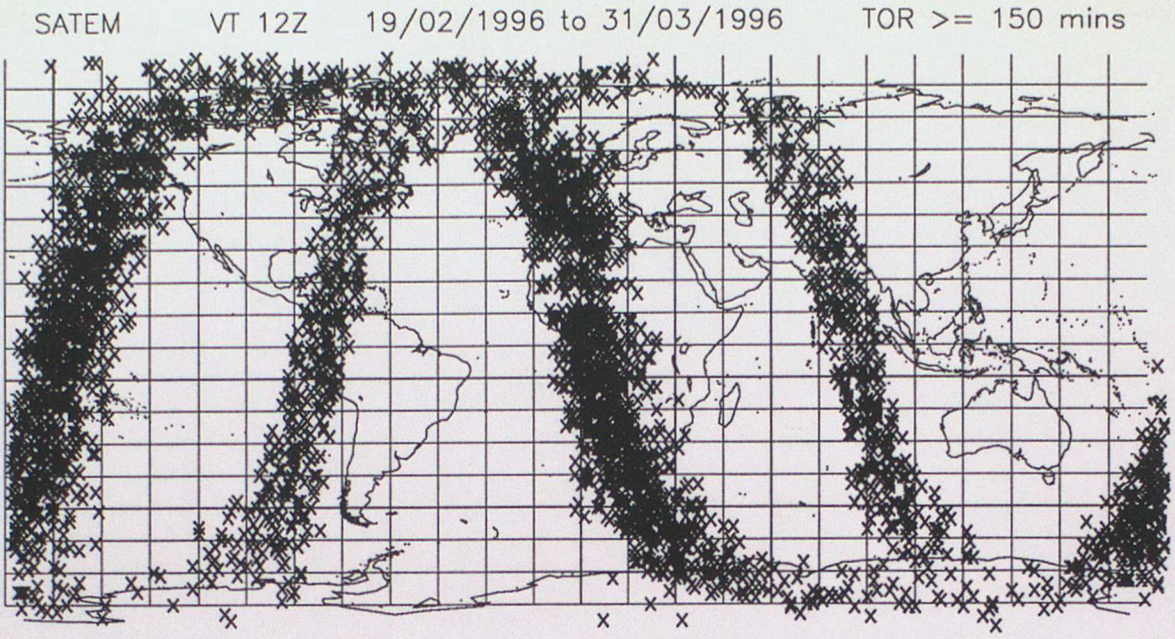
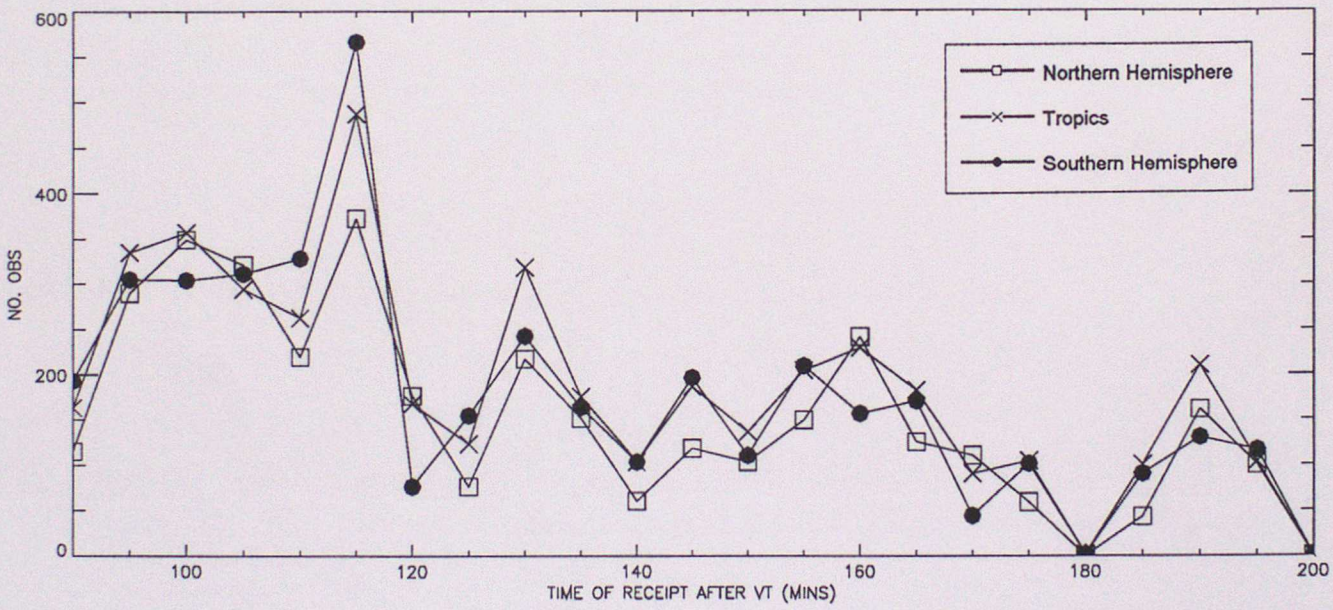

ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.7


SATEM
VT 12Z
19/02/1996 to 31/03/1996
TOR >= 150 mins


600
400
200
0
NO. OBS
Northern Hemisphere
Tropics
Southern Hemisphere
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

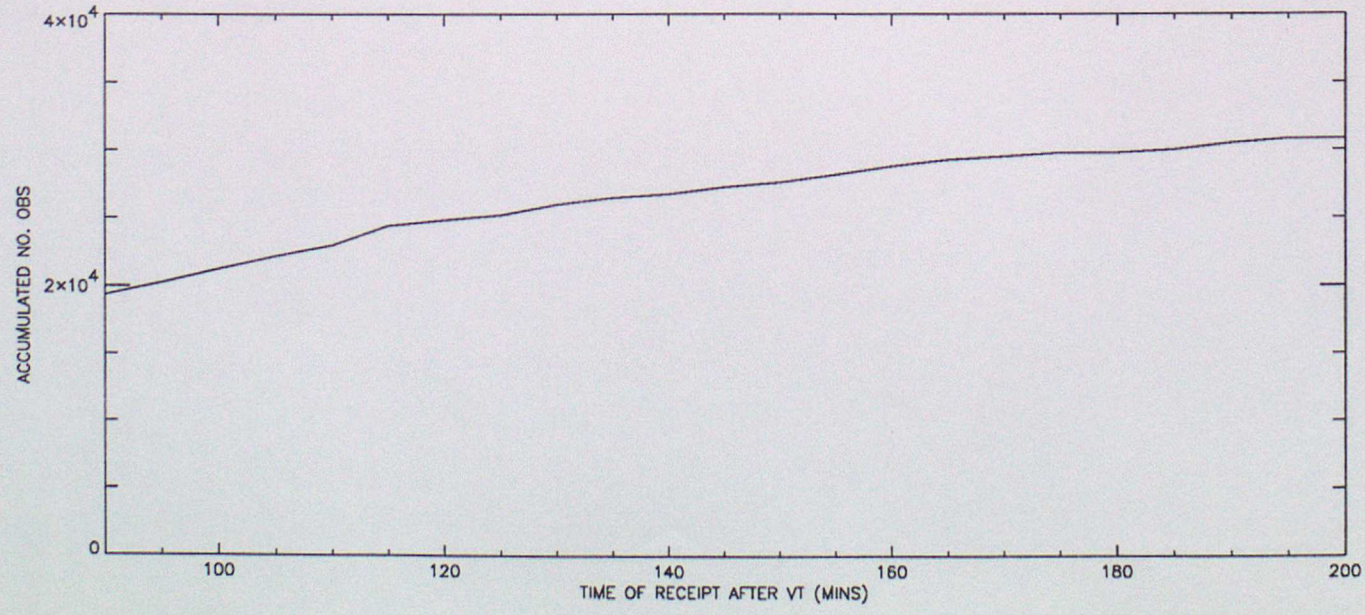
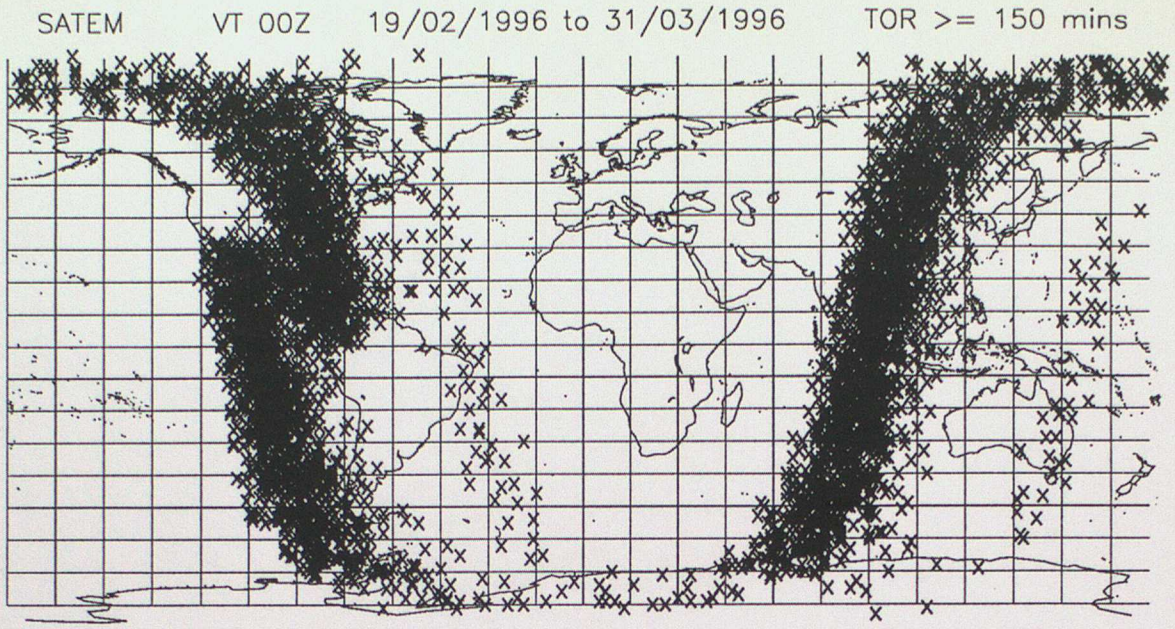
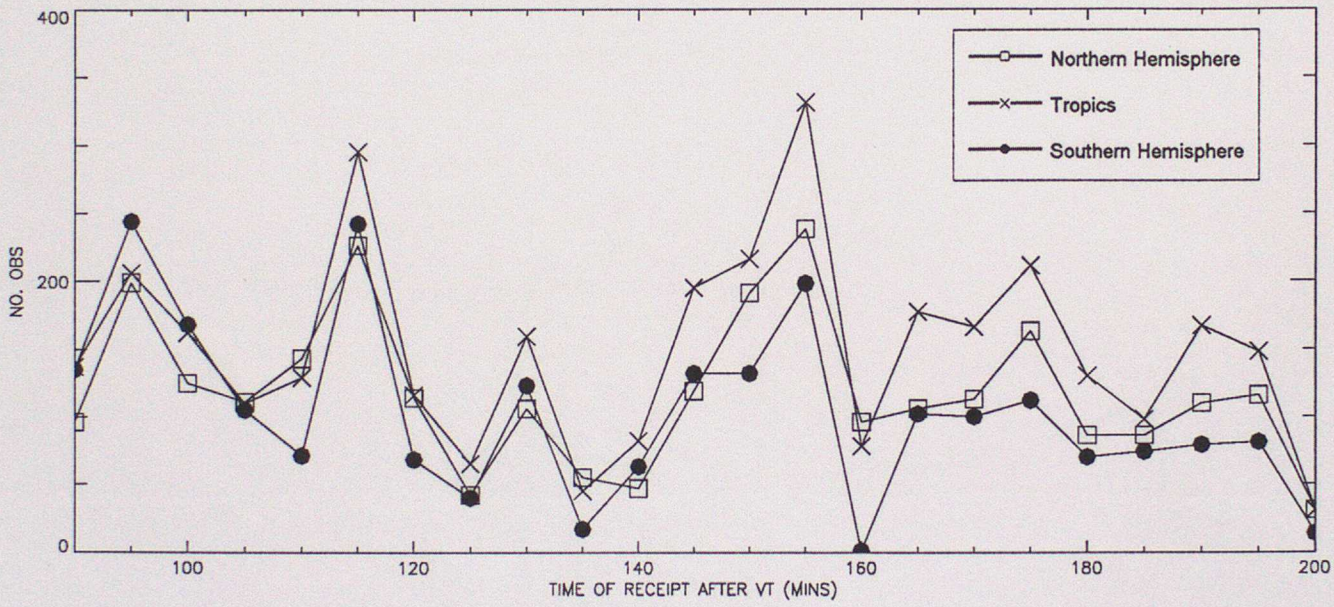

4×10^4
2×10^4
0
ACCUMULATED NO. OBS
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.8a


SATEM
VT 00Z
19/02/1996 to 31/03/1996
TOR >= 150 mins


Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
400
200
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

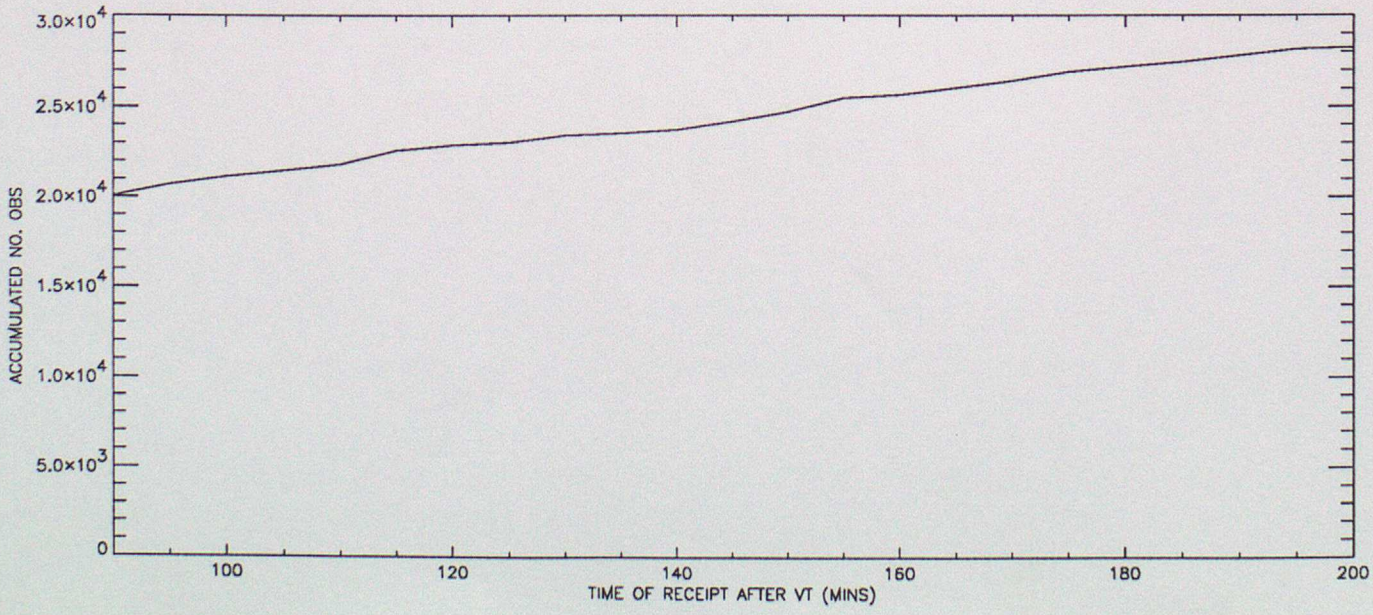

ACCUMULATED NO. OBS
3.0×10^4
2.5×10^4
2.0×10^4
1.5×10^4
1.0×10^4
5.0×10^3
0
100
120
140
160
180
200
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.8b

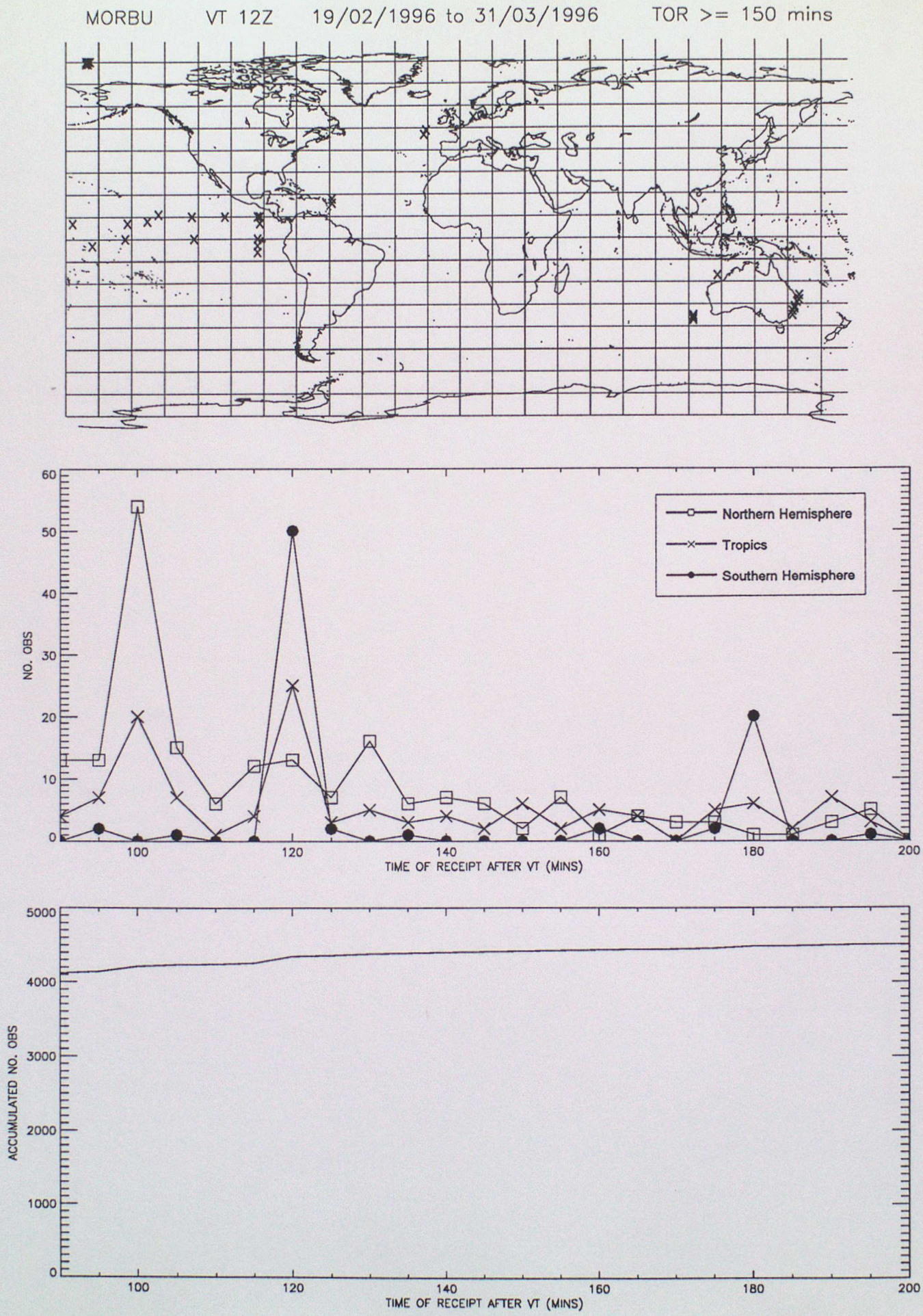

MORBU VT 12Z 19/02/1996 to 31/03/1996 TOR >= 150 mins
Northern Hemisphere
Tropics
Southern Hemisphere
NO. OBS
TIME OF RECEIPT AFTER VT (MINS)
ACCUMULATED NO. OBS
TIME OF RECEIPT AFTER VT (MINS)

FIGURE 2.9

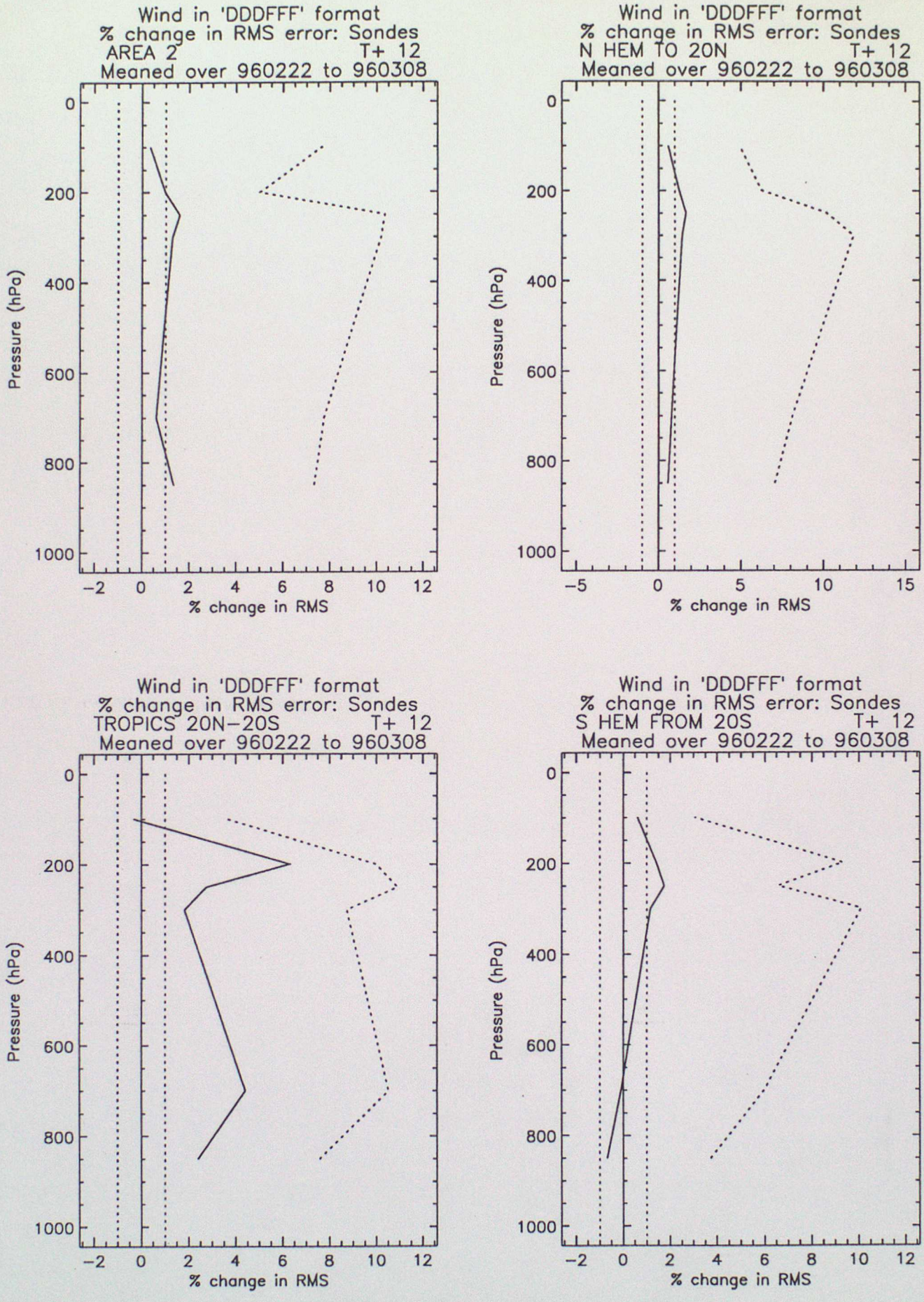

Wind in 'DDDFFF' format
% change in RMS error: Sondes
AREA 2 T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
N HEM TO 20N T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
TROPICS 20N–20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
S HEM FROM 20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.1

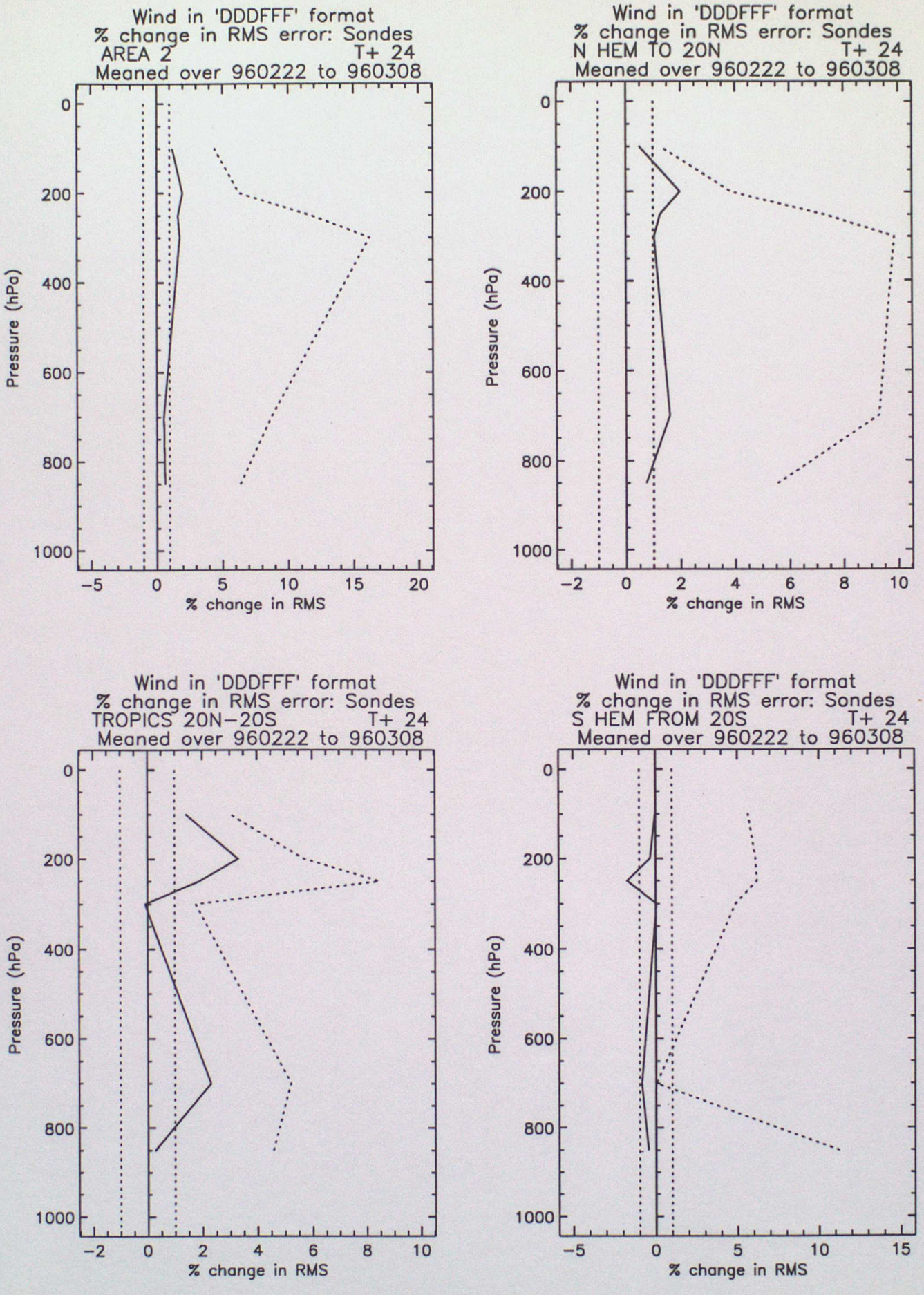
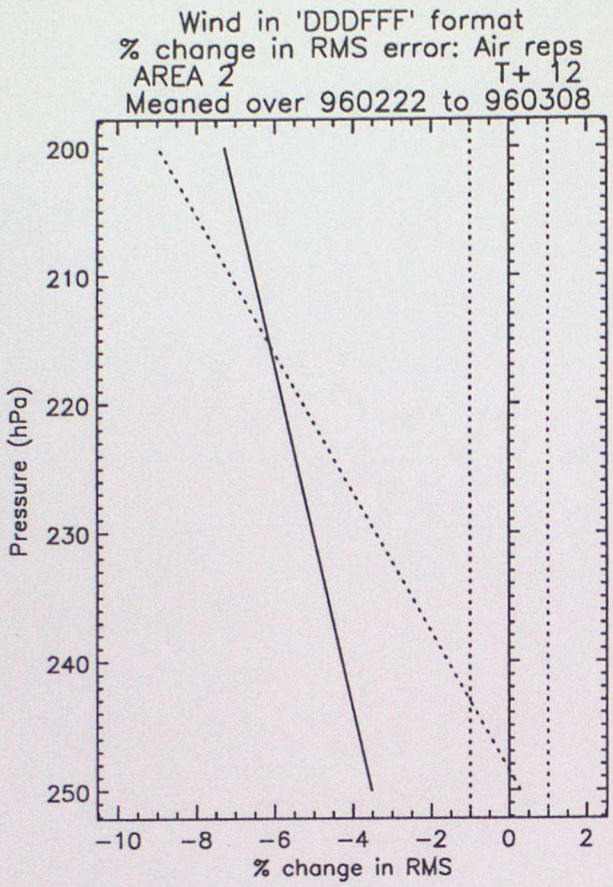
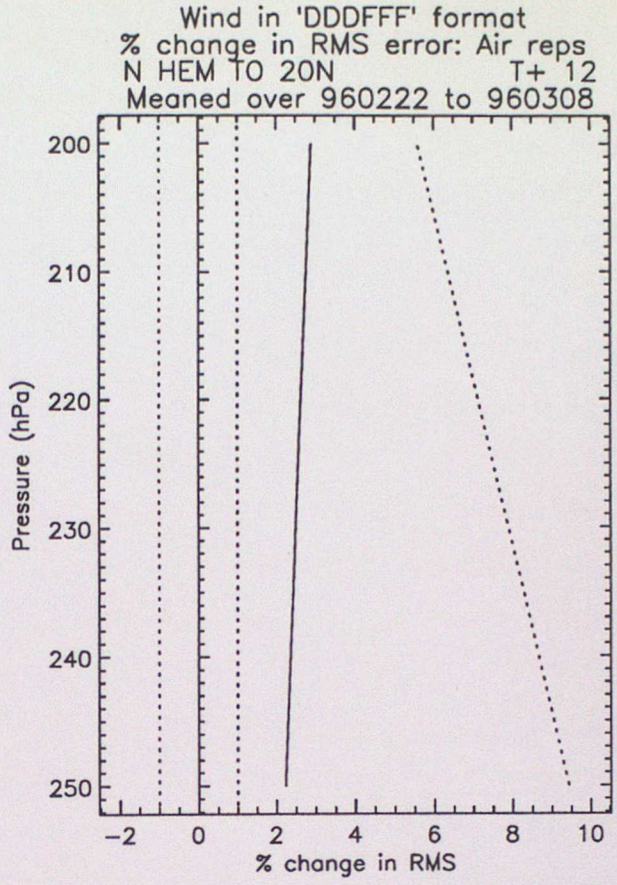
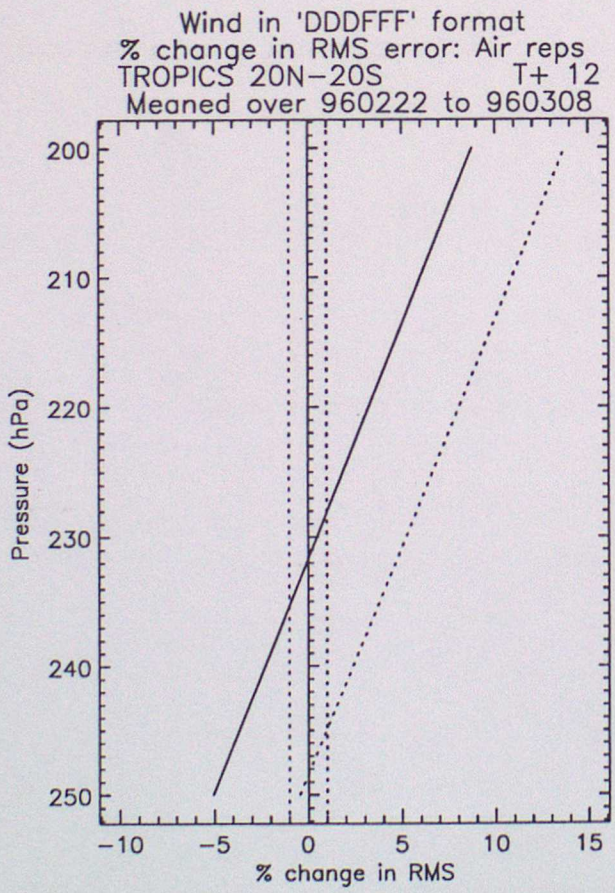

Wind in 'DDDFFF' format
% change in RMS error: Sondes
AREA 2 T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
N HEM TO 20N T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
TROPICS 20N–20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
S HEM FROM 20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.2


Wind in 'DDDFFF' format
% change in RMS error: Air reps
AREA 2 T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
200
210
220
230
240
250
−10 −8 −6 −4 −2 0 2
% change in RMS


Wind in 'DDDFFF' format
% change in RMS error: Air reps
N HEM TO 20N T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
200
210
220
230
240
250
−2 0 2 4 6 8 10
% change in RMS


Wind in 'DDDFFF' format
% change in RMS error: Air reps
TROPICS 20N−20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
200
210
220
230
240
250
−10 −5 0 5 10 15
% change in RMS

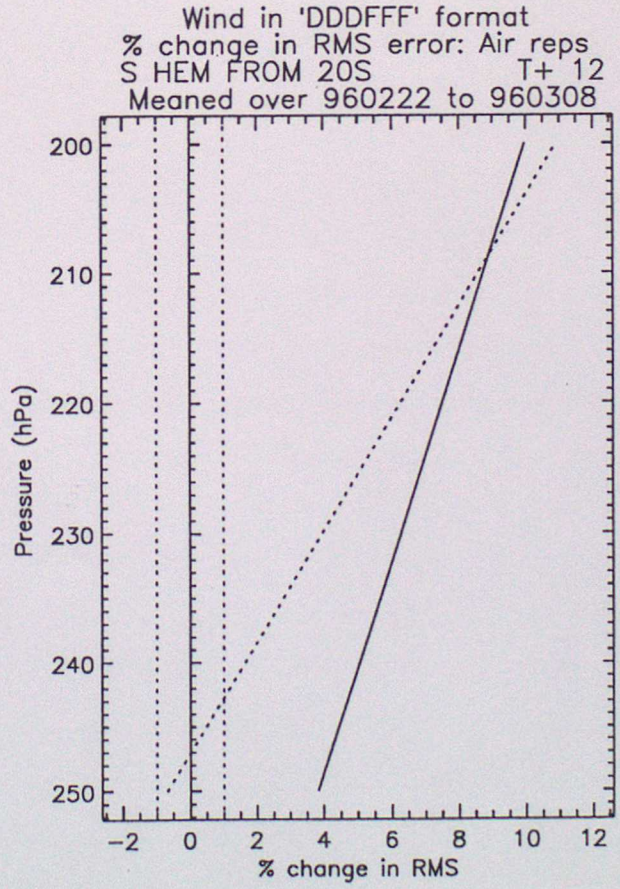

Wind in 'DDDFFF' format
% change in RMS error: Air reps
S HEM FROM 20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
200
210
220
230
240
250
−2 0 2 4 6 8 10 12
% change in RMS

FIGURE 3.3

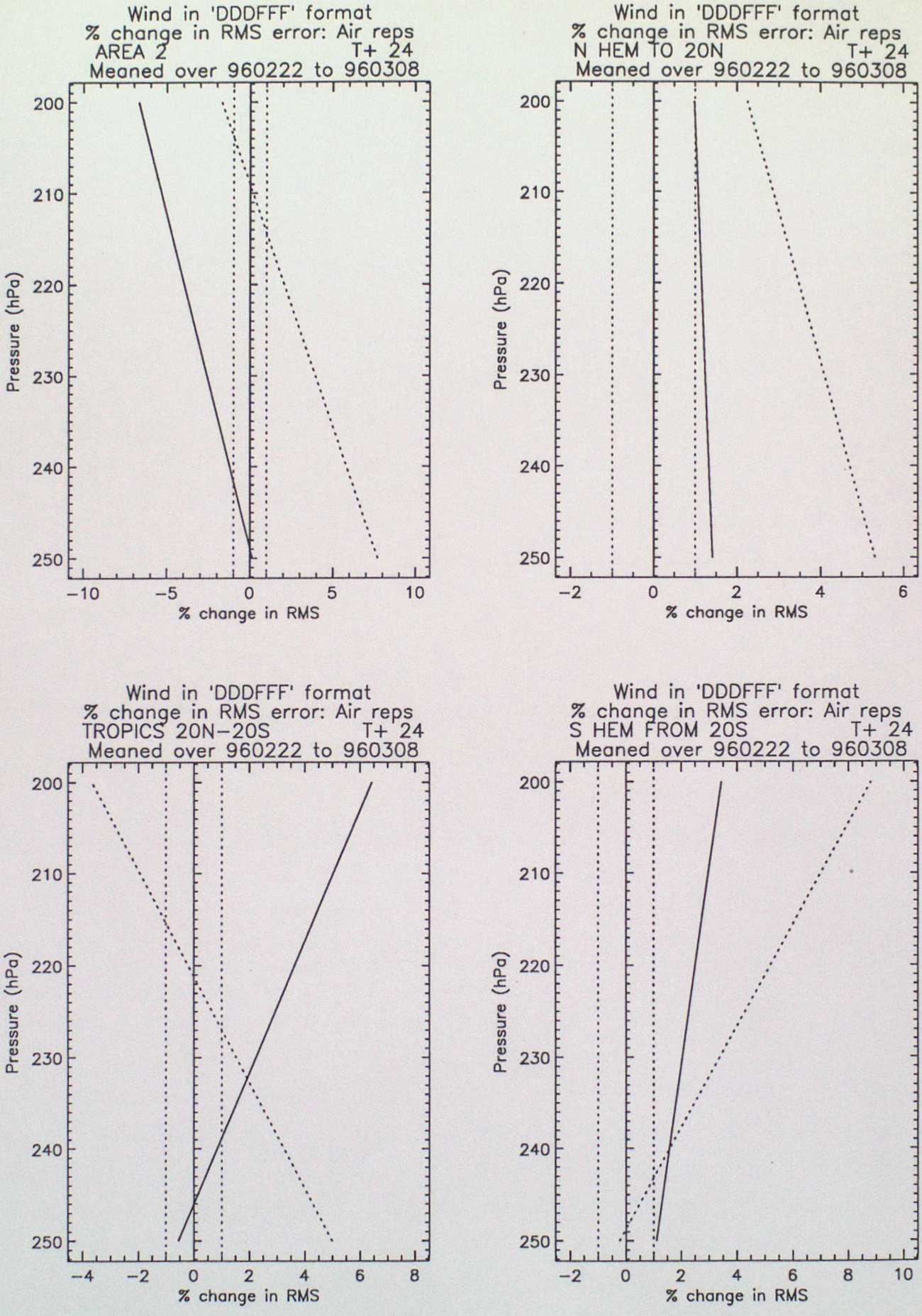

Wind in 'DDDFFF' format
% change in RMS error: Air reps
AREA 2 T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
N HEM TO 20N T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
TROPICS 20N–20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
S HEM FROM 20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.4

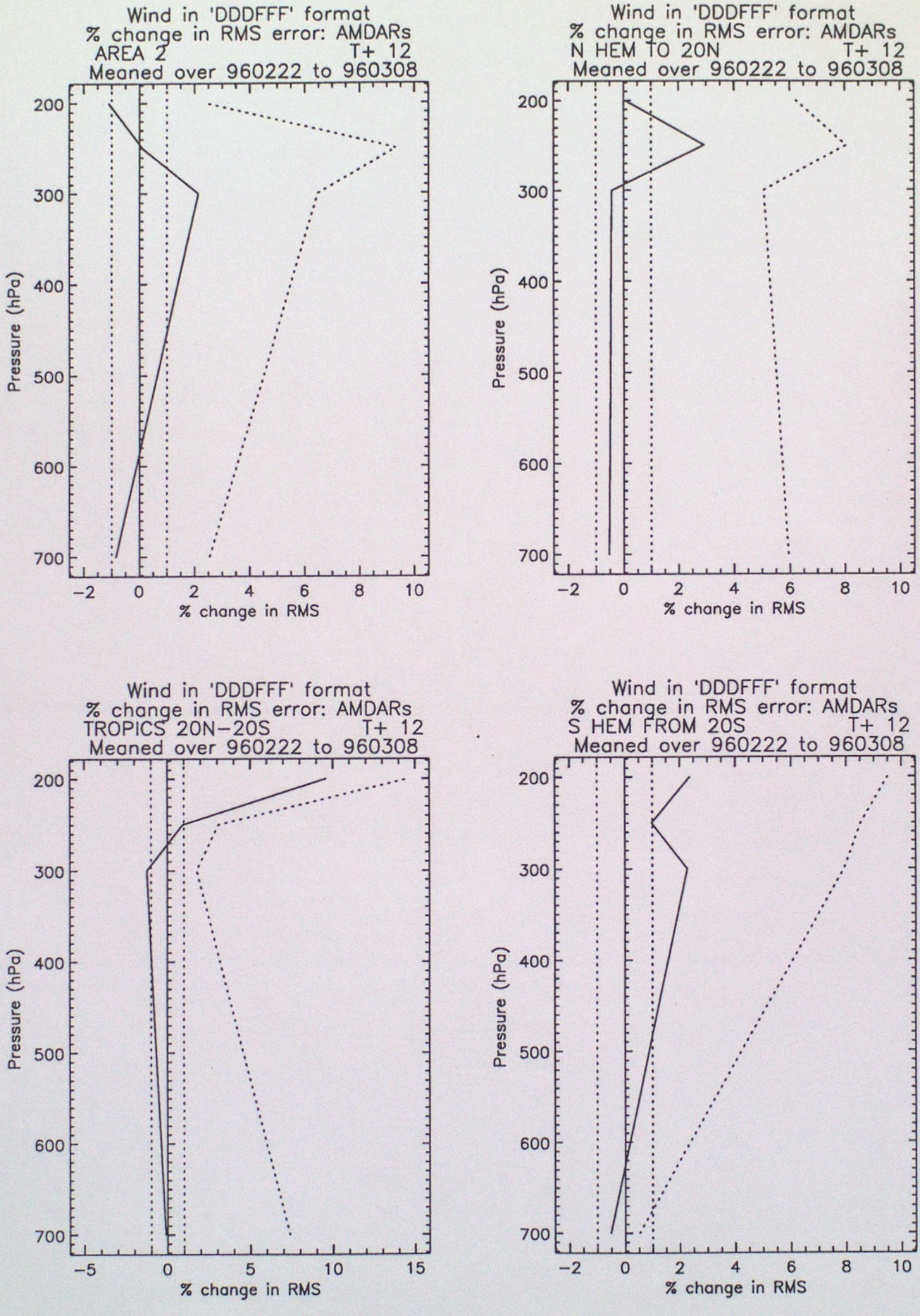

Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
N HEM TO 20N T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
TROPICS 20N–20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
S HEM FROM 20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.5

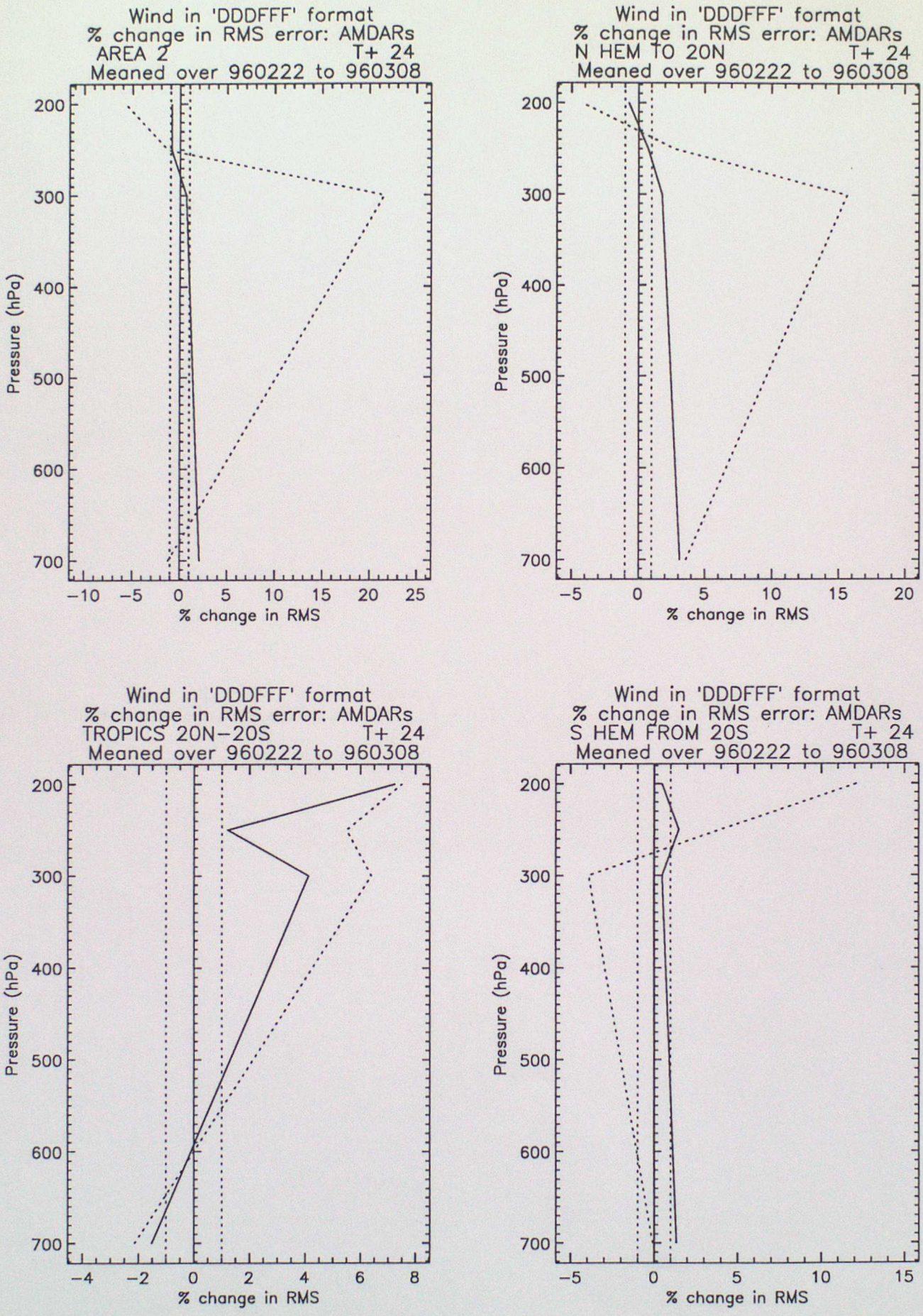

Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
200
300
400
500
600
700
−10 −5 0 5 10 15 20 25
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
N HEM TO 20N T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
200
300
400
500
600
700
−5 0 5 10 15 20
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
TROPICS 20N−20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
200
300
400
500
600
700
−4 −2 0 2 4 6 8
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
S HEM FROM 20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
200
300
400
500
600
700
−5 0 5 10 15
% change in RMS

FIGURE 3.6

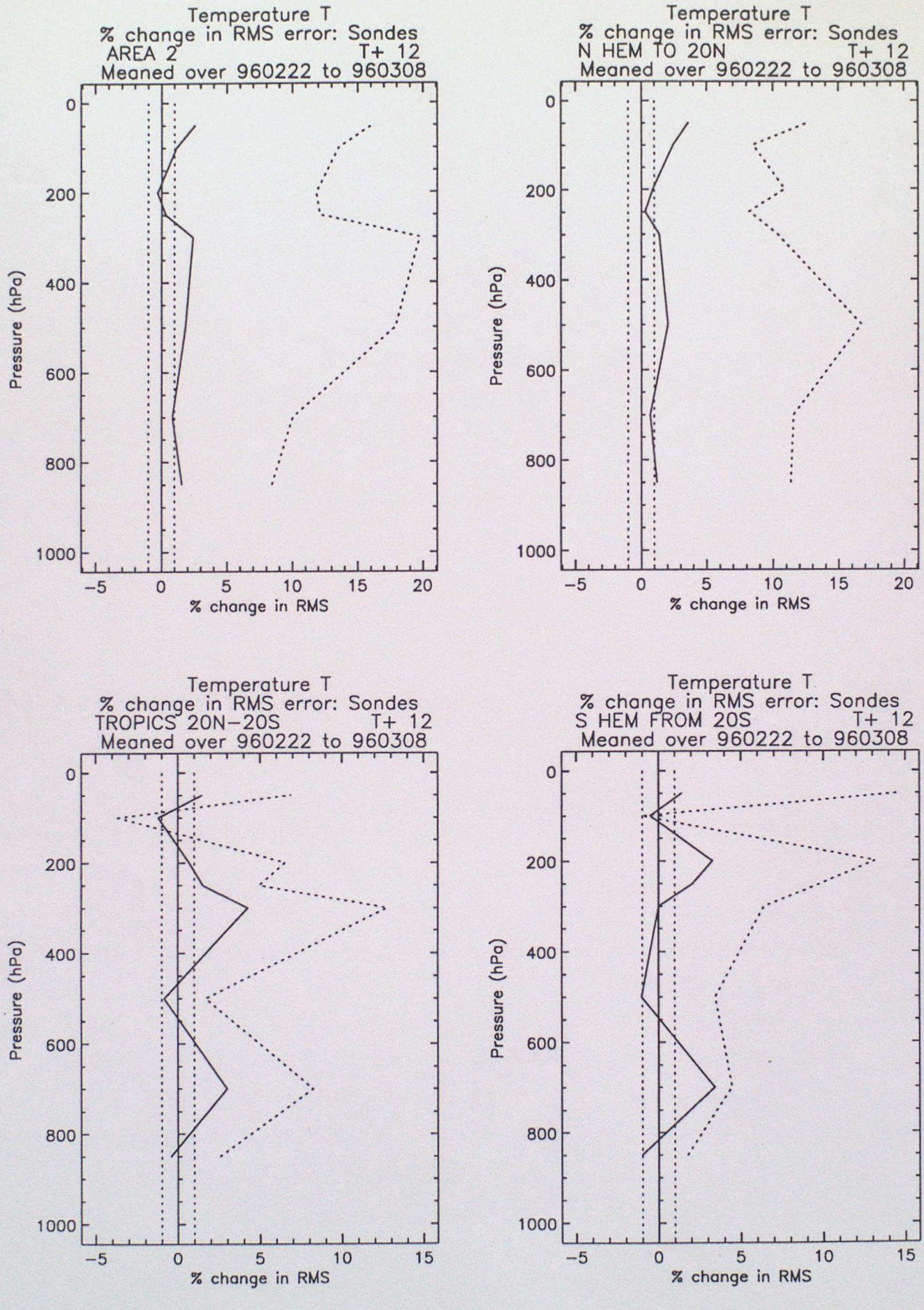

Temperature T
% change in RMS error: Sondes
AREA 2 T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
N HEM TO 20N T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
TROPICS 20N–20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
S HEM FROM 20S T+ 12
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.7

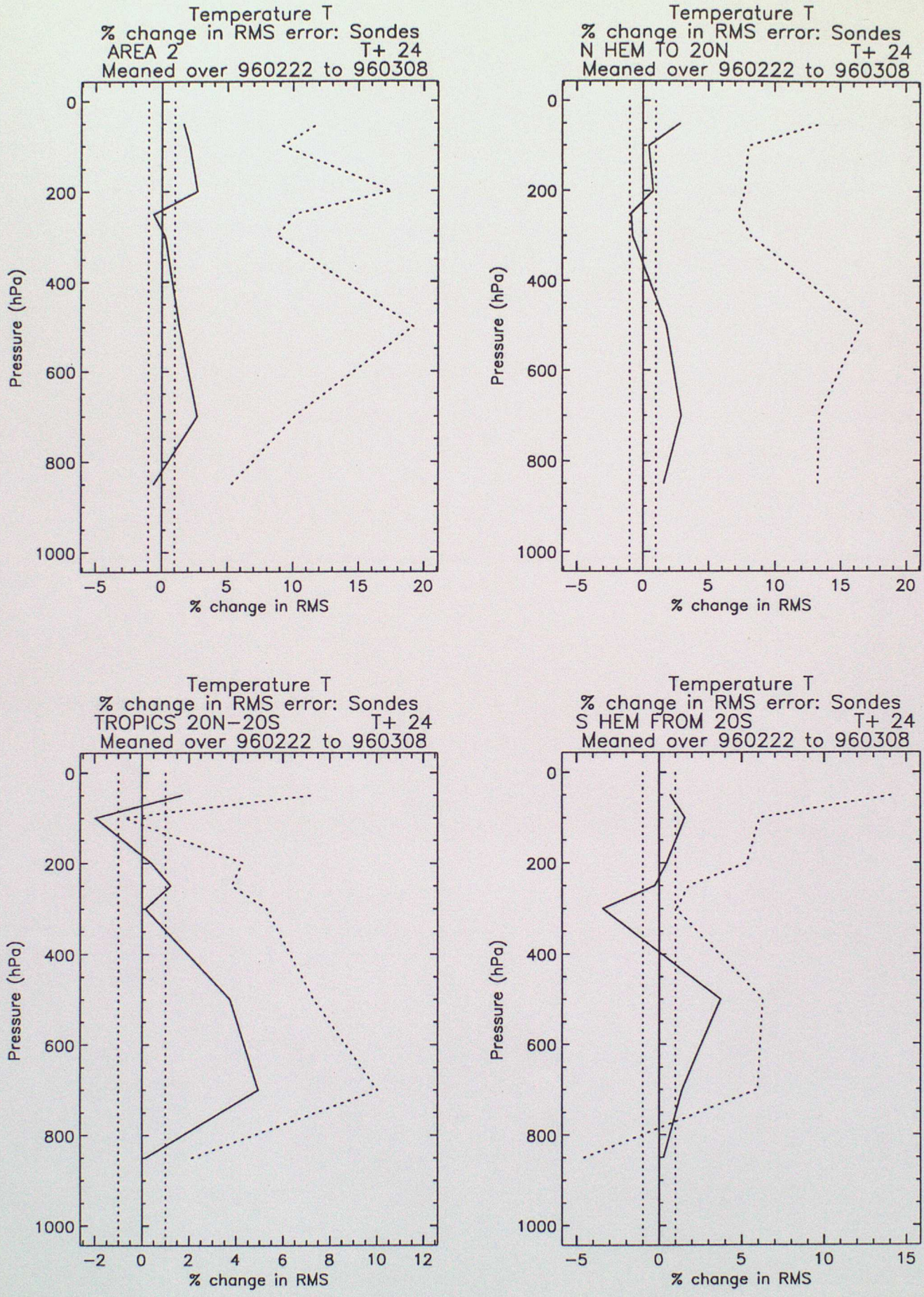

Temperature T
% change in RMS error: Sondes
AREA 2 T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
N HEM TO 20N T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
TROPICS 20N–20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
S HEM FROM 20S T+ 24
Meaned over 960222 to 960308
Pressure (hPa)
% change in RMS

FIGURE 3.8

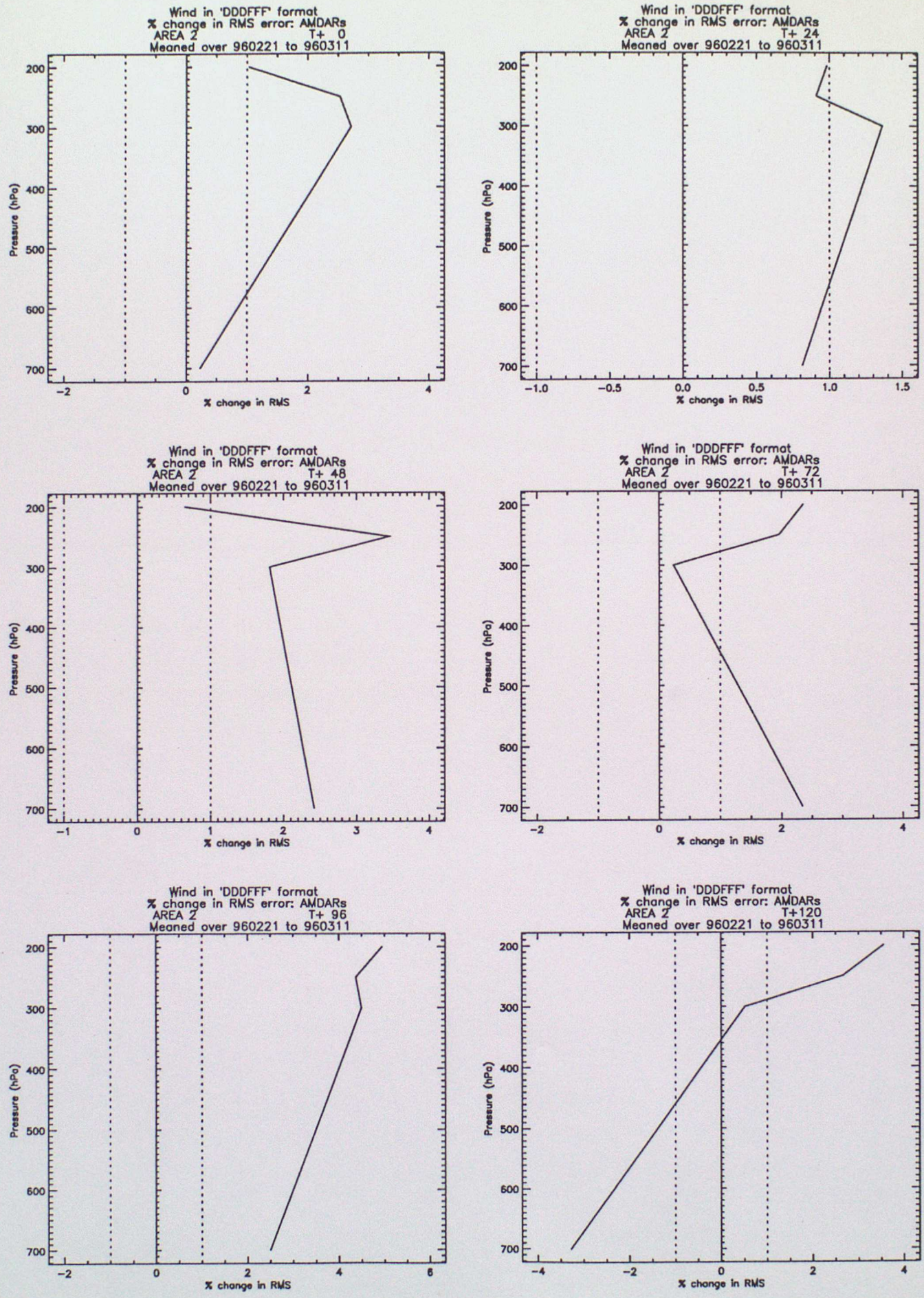

Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 0
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 24
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 48
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 72
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 96
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+120
Meaned over 960221 to 960311
Pressure (hPa)
% change in RMS

FIGURE 3.9

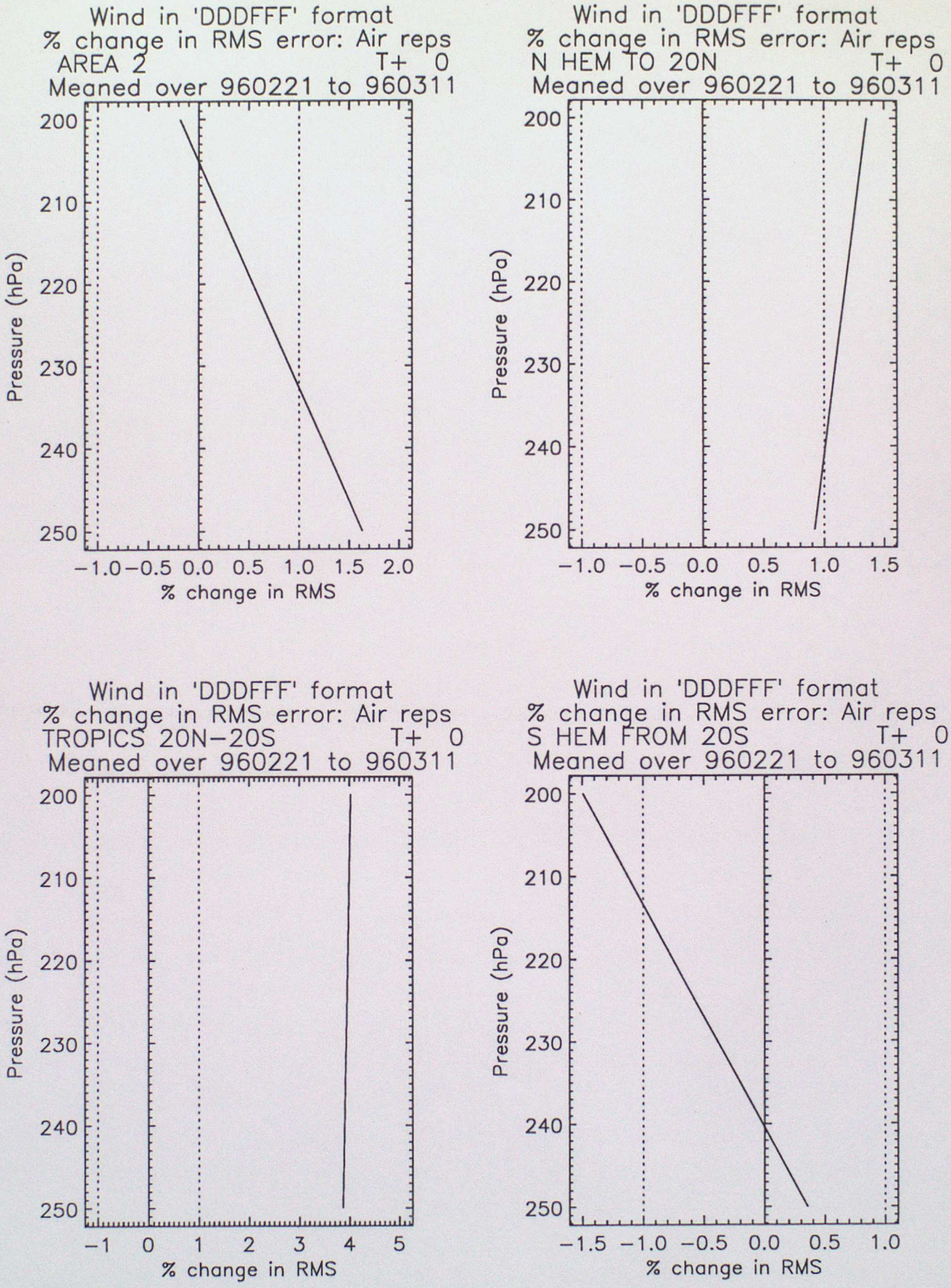

Wind in 'DDDFFF' format
% change in RMS error: Air reps
AREA 2 T+ 0
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
N HEM TO 20N T+ 0
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−1.0 −0.5 0.0 0.5 1.0 1.5
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
TROPICS 20N−20S T+ 0
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−1 0 1 2 3 4 5
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
S HEM FROM 20S T+ 0
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−1.5 −1.0 −0.5 0.0 0.5 1.0
% change in RMS

FIGURE 3.10

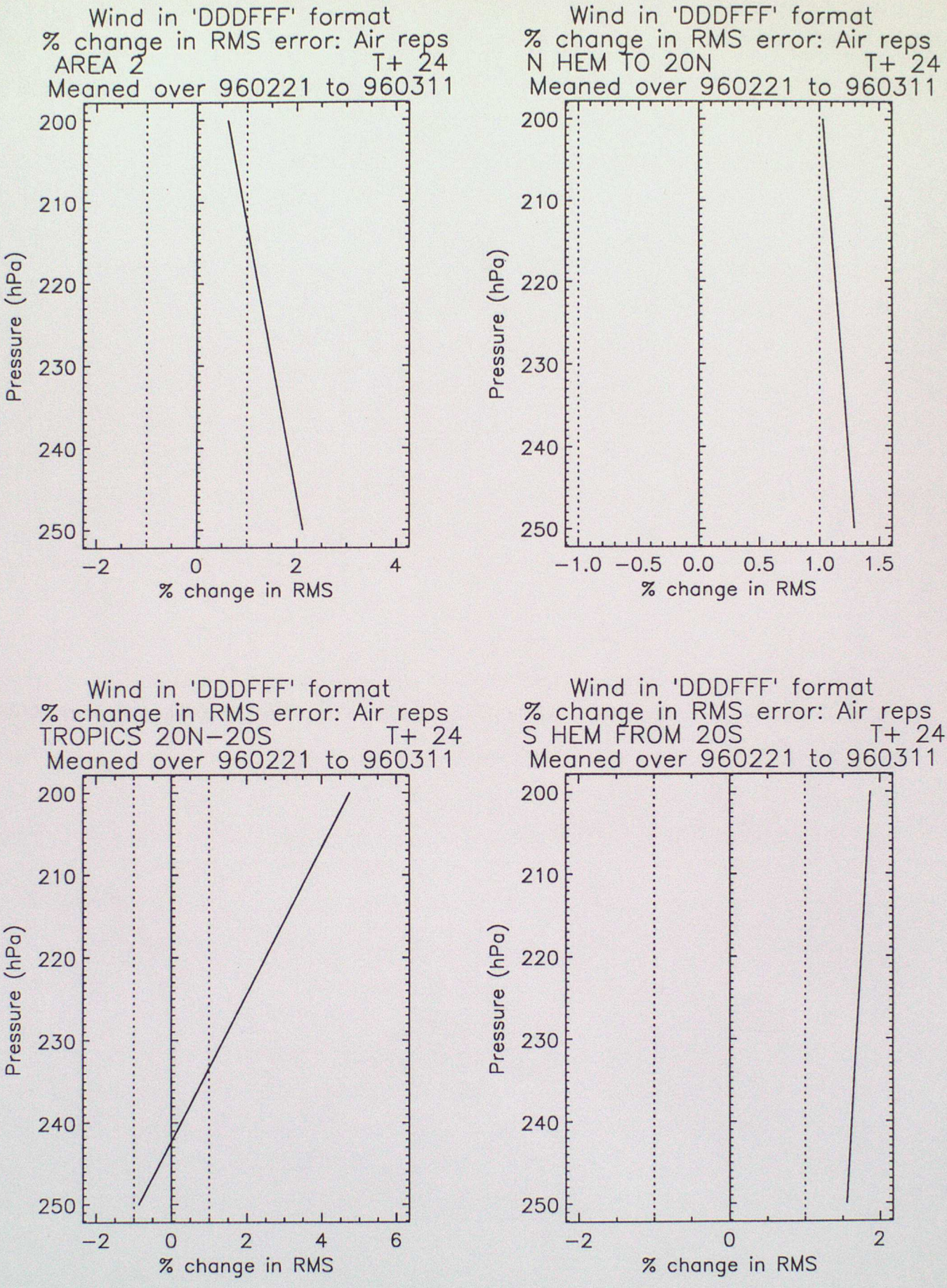

Wind in 'DDDFFF' format
% change in RMS error: Air reps
AREA 2 T+ 24
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−2
0
2
4
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
N HEM TO 20N T+ 24
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−1.0
−0.5
0.0
0.5
1.0
1.5
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
TROPICS 20N−20S T+ 24
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−2
0
2
4
6
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Air reps
S HEM FROM 20S T+ 24
Meaned over 960221 to 960311
Pressure (hPa)
200
210
220
230
240
250
−2
0
2
% change in RMS

FIGURE 3.11

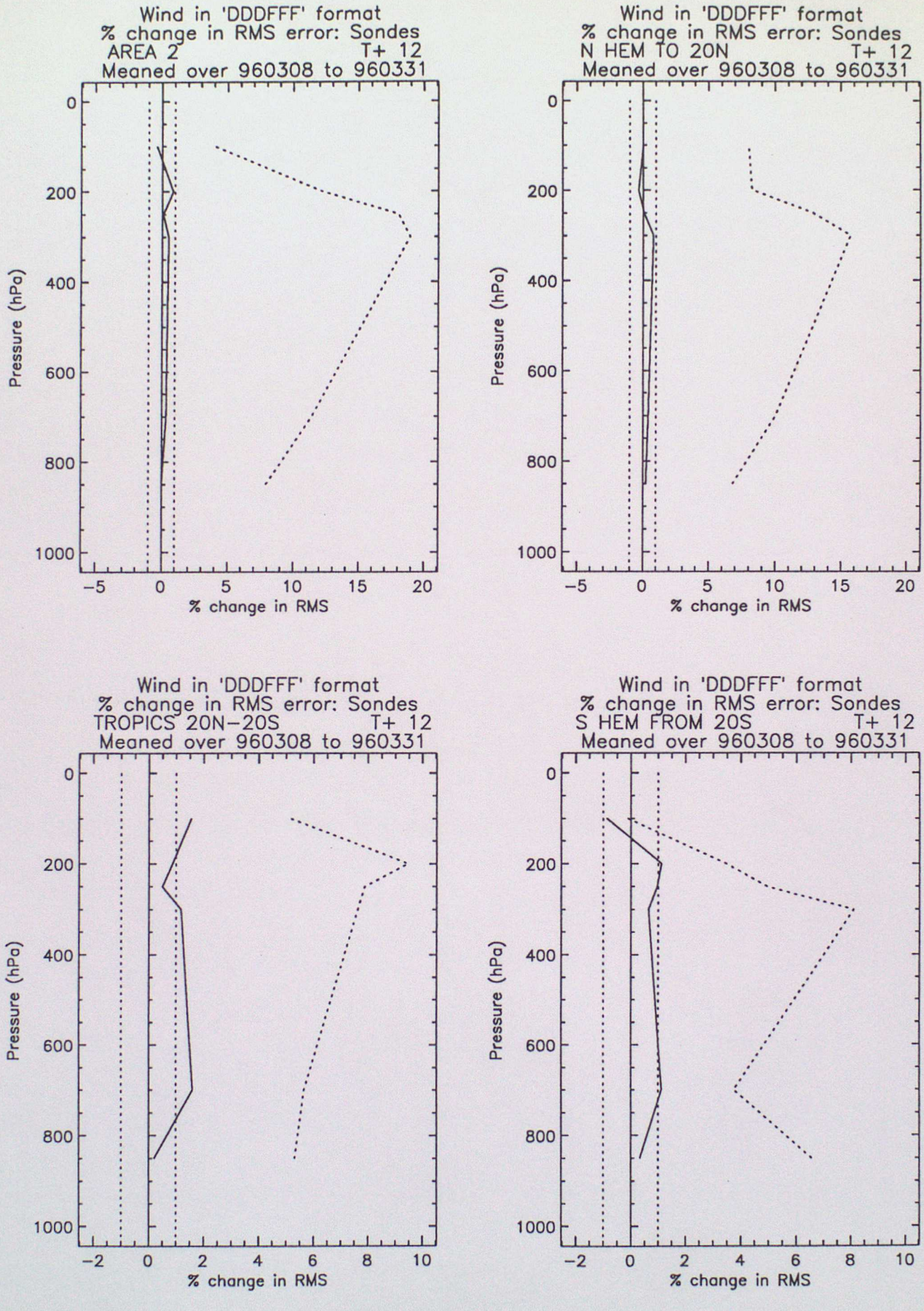

Wind in 'DDDFFF' format
% change in RMS error: Sondes
AREA 2 T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
N HEM TO 20N T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
TROPICS 20N–20S T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
S HEM FROM 20S T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS

FIGURE 3.12

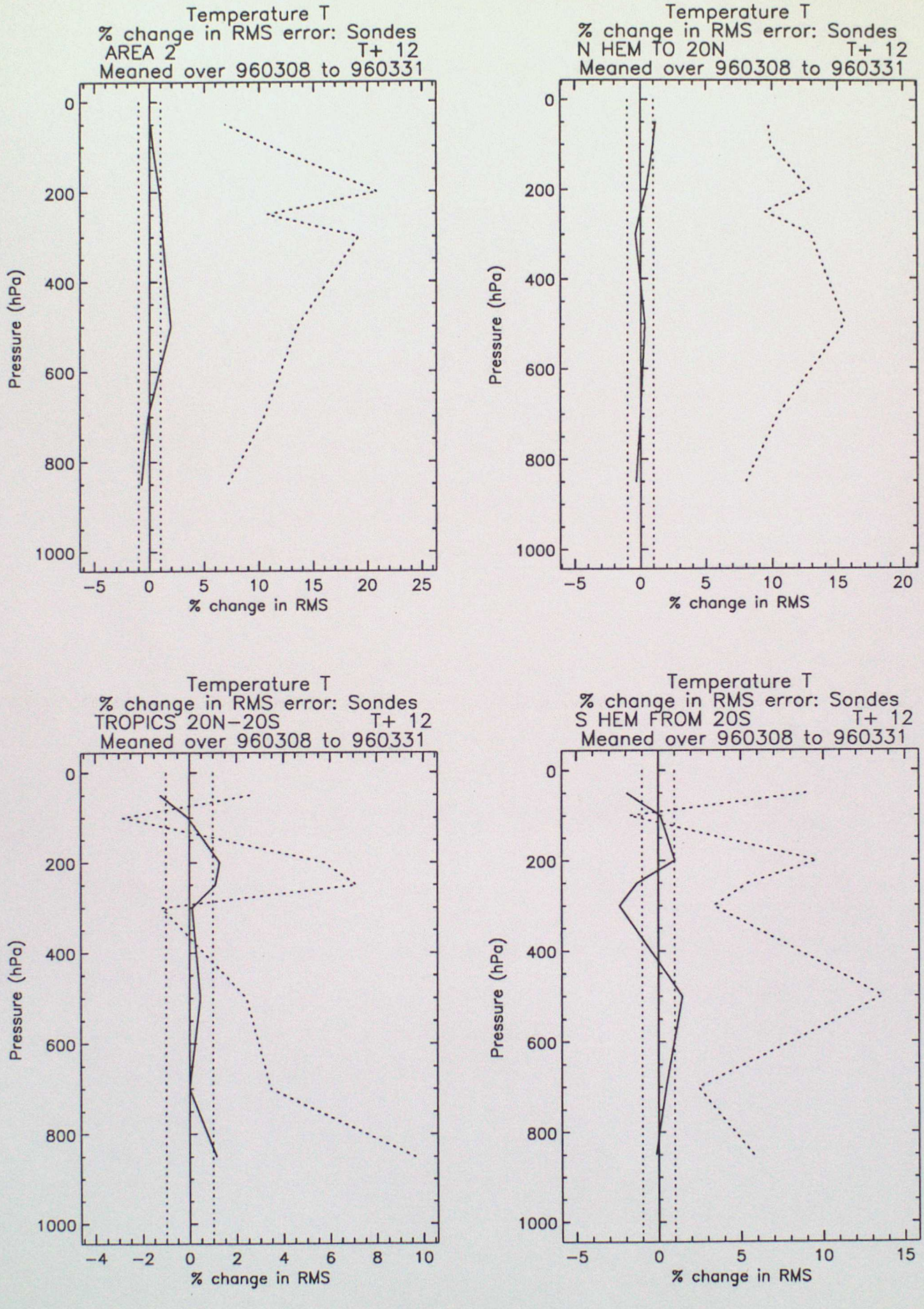

Temperature T
% change in RMS error: Sondes
AREA 2 T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
N HEM TO 20N T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
TROPICS 20N−20S T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS
Temperature T
% change in RMS error: Sondes
S HEM FROM 20S T+ 12
Meaned over 960308 to 960331
Pressure (hPa)
% change in RMS

FIGURE 3.13

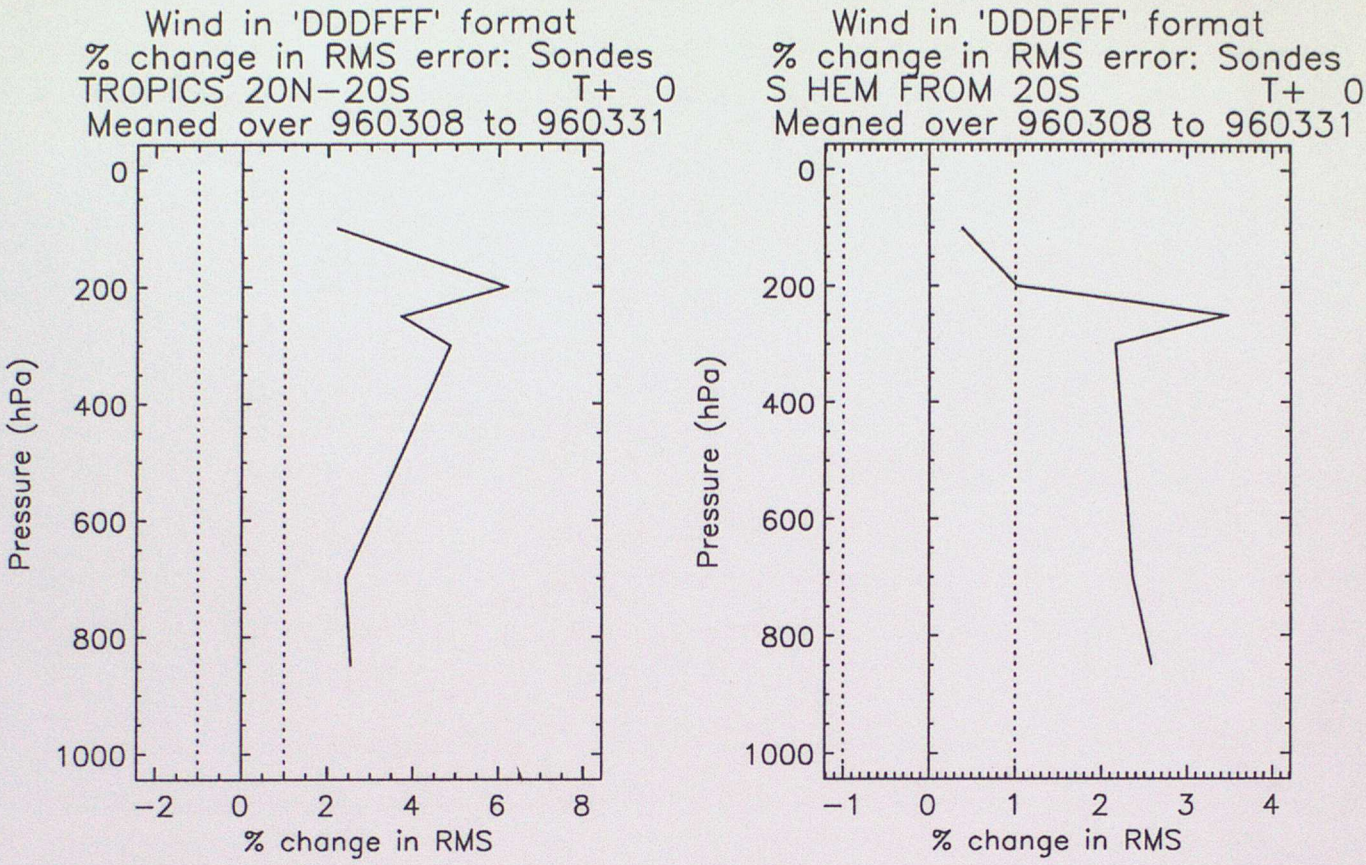

Wind in 'DDDFFF' format
% change in RMS error: Sondes
TROPICS 20N–20S T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
–2
0
2
4
6
8
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Sondes
S HEM FROM 20S T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
–1
0
1
2
3
4
% change in RMS

FIGURE 3.14

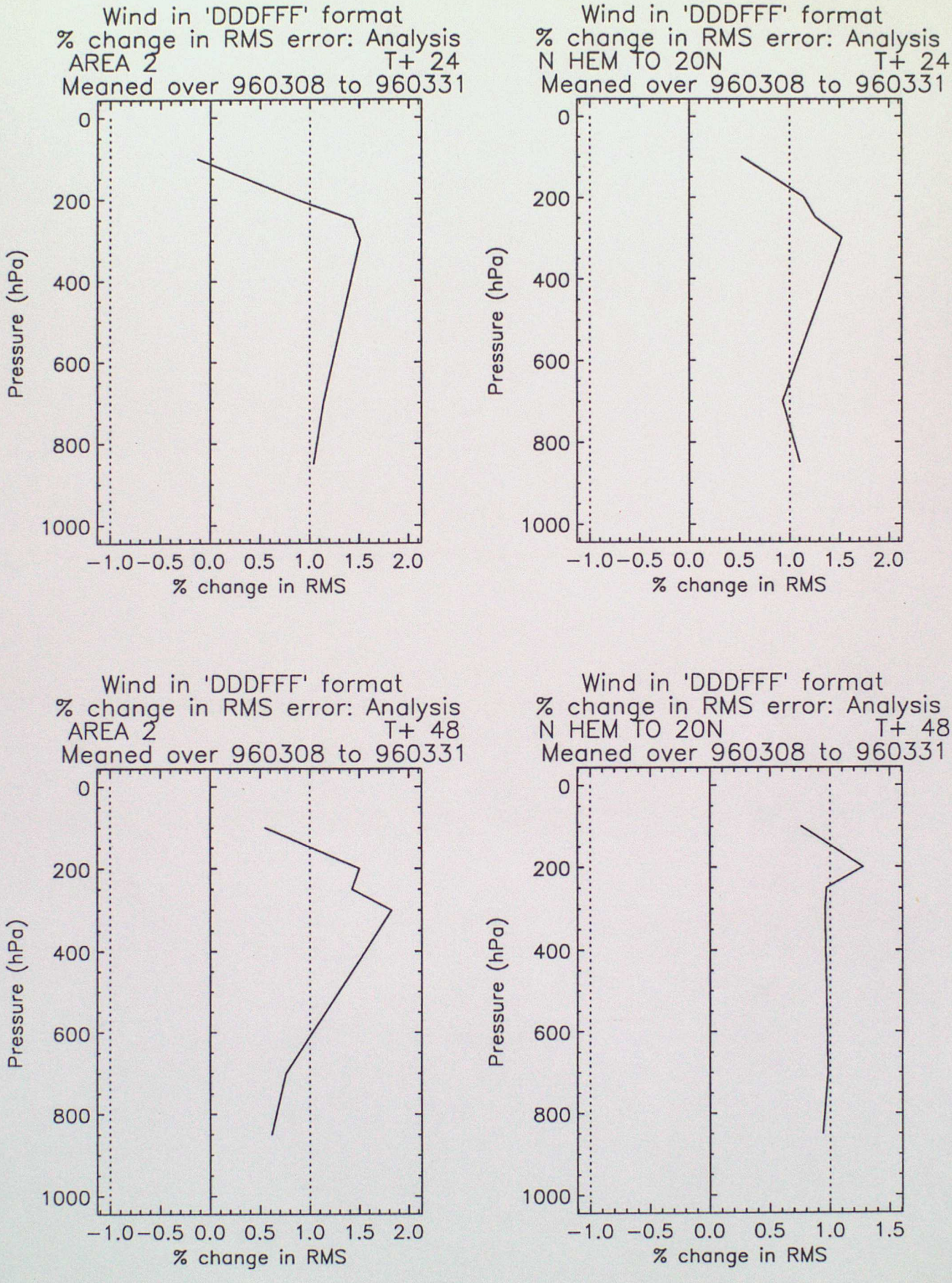

Wind in 'DDDFFF' format
% change in RMS error: Analysis
AREA 2
T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Analysis
N HEM TO 20N
T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Analysis
AREA 2
T+ 48
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: Analysis
N HEM TO 20N
T+ 48
Meaned over 960308 to 960331
Pressure (hPa)
0
200
400
600
800
1000
−1.0 −0.5 0.0 0.5 1.0 1.5
% change in RMS

FIGURE 3.15

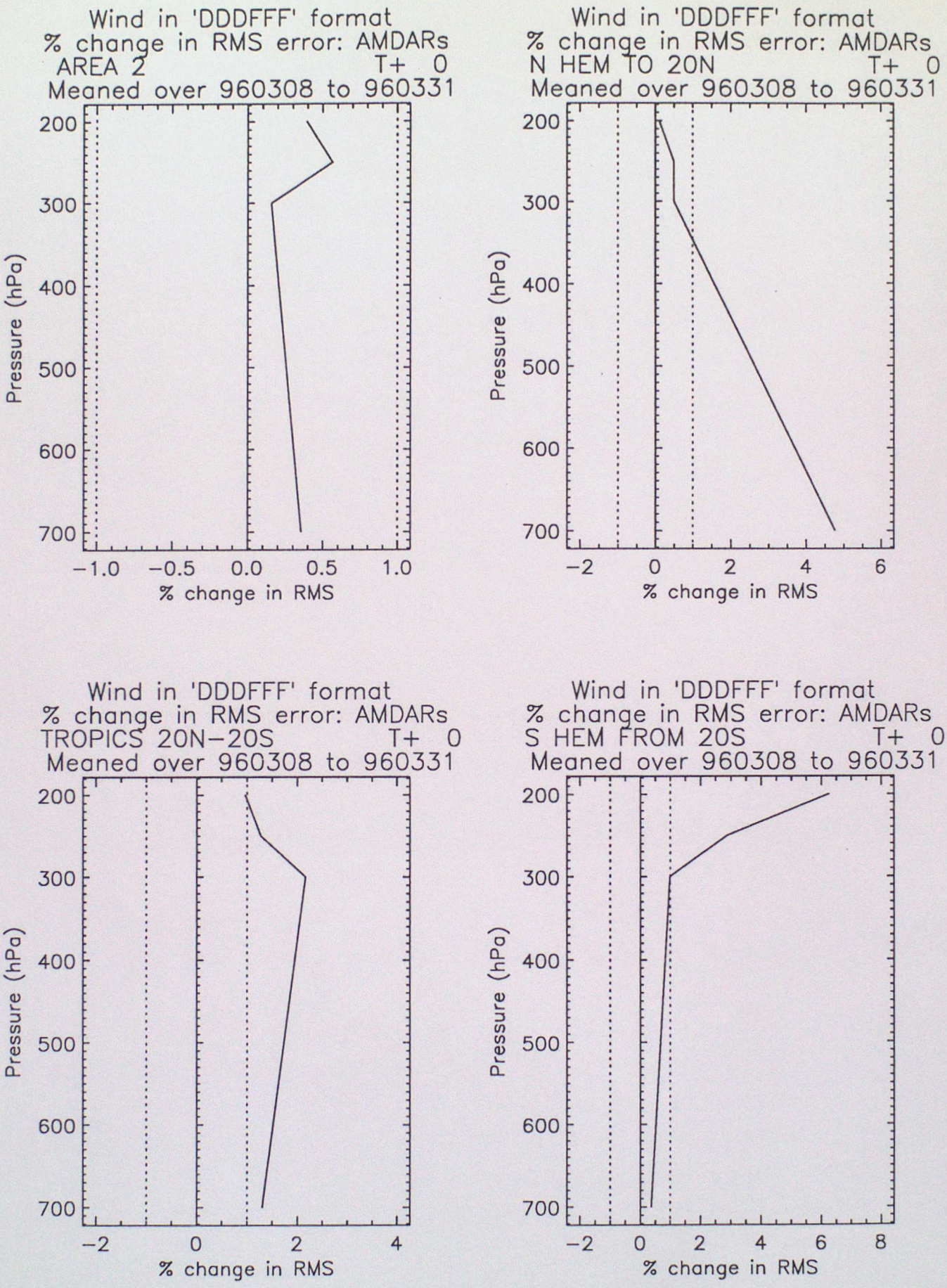

Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−1.0 −0.5 0.0 0.5 1.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
N HEM TO 20N T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−2 0 2 4 6
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
TROPICS 20N−20S T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−2 0 2 4
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
S HEM FROM 20S T+ 0
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−2 0 2 4 6 8
% change in RMS

FIGURE 3.16

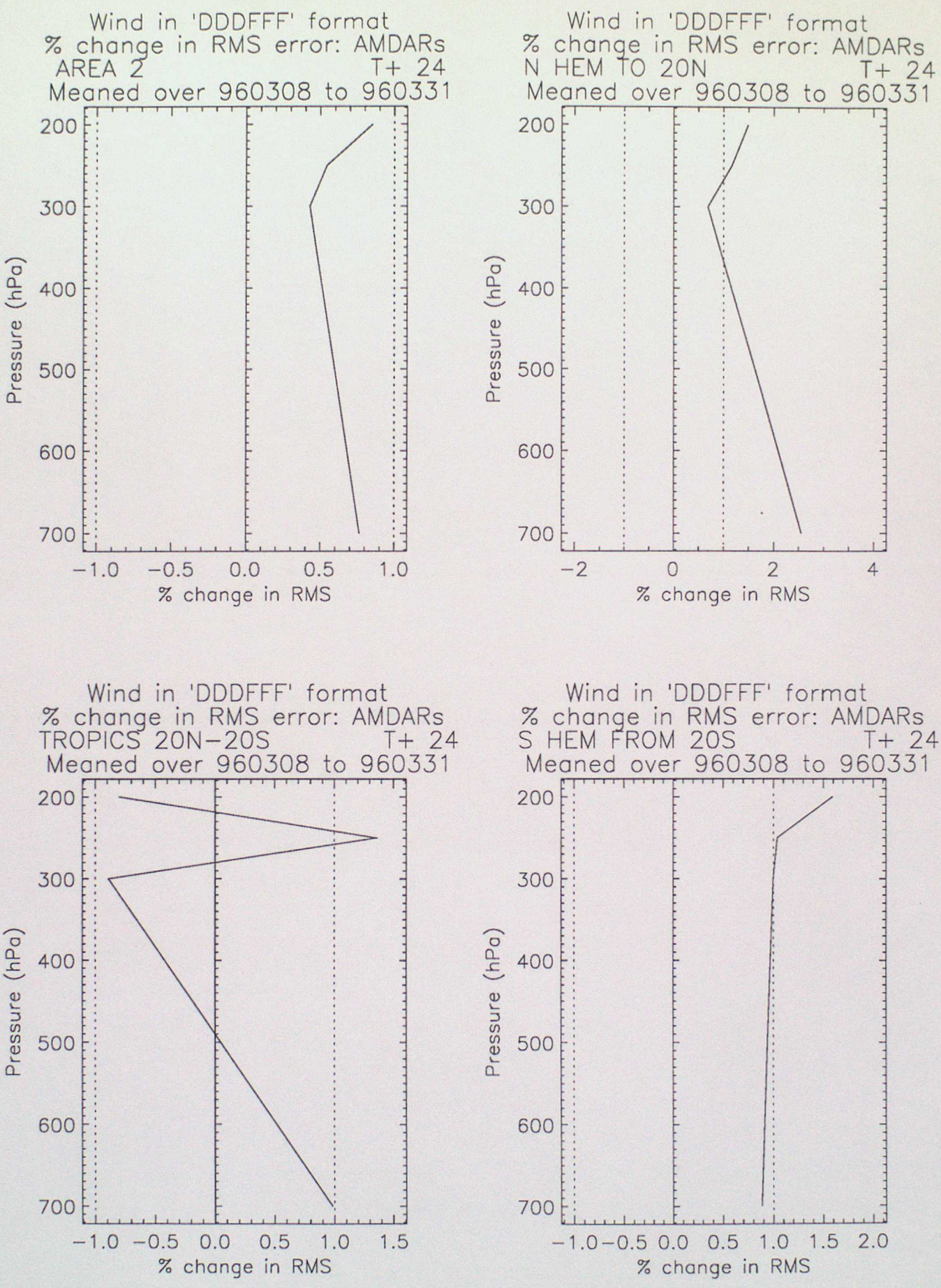

Wind in 'DDDFFF' format
% change in RMS error: AMDARs
AREA 2 T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−1.0 −0.5 0.0 0.5 1.0
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
N HEM TO 20N T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−2 0 2 4
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
TROPICS 20N−20S T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−1.0 −0.5 0.0 0.5 1.0 1.5
% change in RMS
Wind in 'DDDFFF' format
% change in RMS error: AMDARs
S HEM FROM 20S T+ 24
Meaned over 960308 to 960331
Pressure (hPa)
200
300
400
500
600
700
−1.0 −0.5 0.0 0.5 1.0 1.5 2.0
% change in RMS

FIGURE 3.17

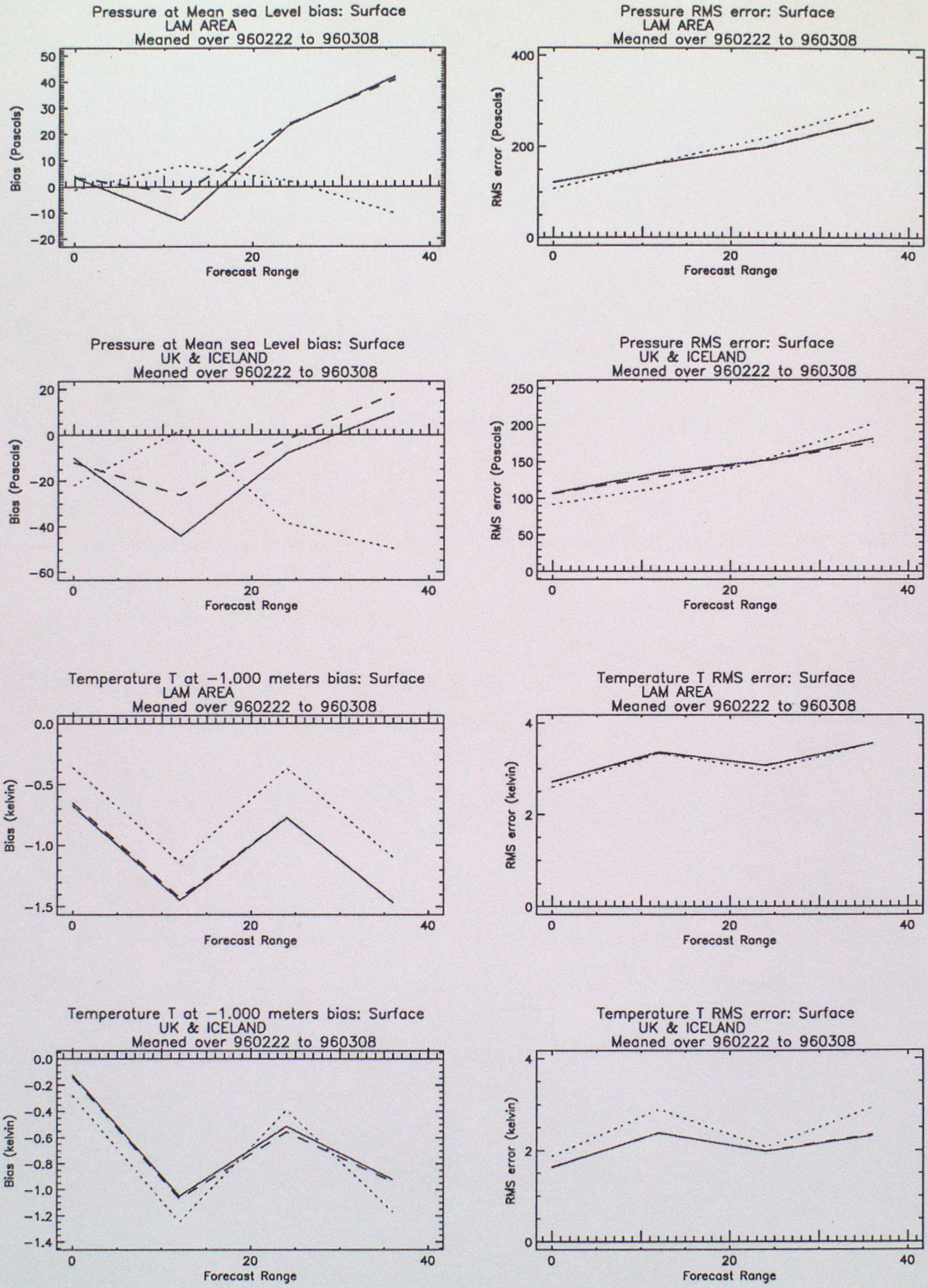
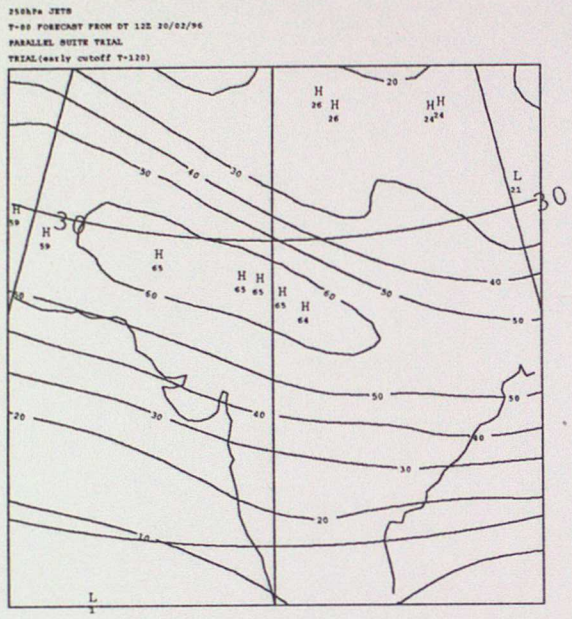
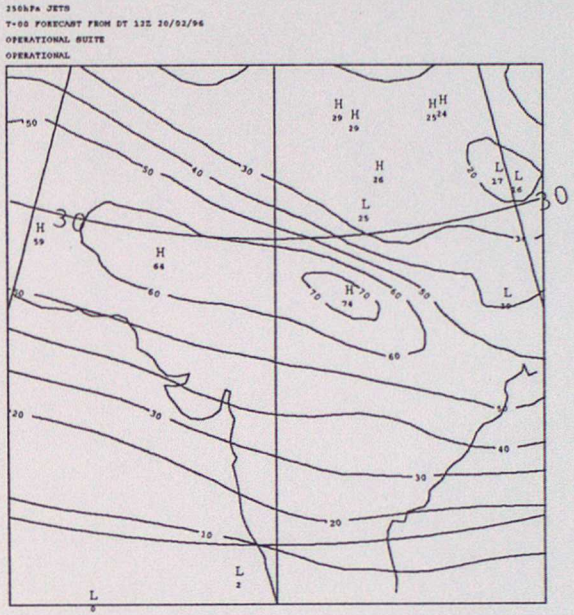

Pressure at Mean sea Level bias: Surface
LAM AREA
Meaned over 960222 to 960308
Bias (Pascals)
Forecast Range
Pressure RMS error: Surface
LAM AREA
Meaned over 960222 to 960308
RMS error (Pascals)
Forecast Range
Pressure at Mean sea Level bias: Surface
UK & ICELAND
Meaned over 960222 to 960308
Bias (Pascals)
Forecast Range
Pressure RMS error: Surface
UK & ICELAND
Meaned over 960222 to 960308
RMS error (Pascals)
Forecast Range
Temperature T at −1.000 meters bias: Surface
LAM AREA
Meaned over 960222 to 960308
Bias (kelvin)
Forecast Range
Temperature T RMS error: Surface
LAM AREA
Meaned over 960222 to 960308
RMS error (kelvin)
Forecast Range
Temperature T at −1.000 meters bias: Surface
UK & ICELAND
Meaned over 960222 to 960308
Bias (kelvin)
Forecast Range
Temperature T RMS error: Surface
UK & ICELAND
Meaned over 960222 to 960308
RMS error (kelvin)
Forecast Range

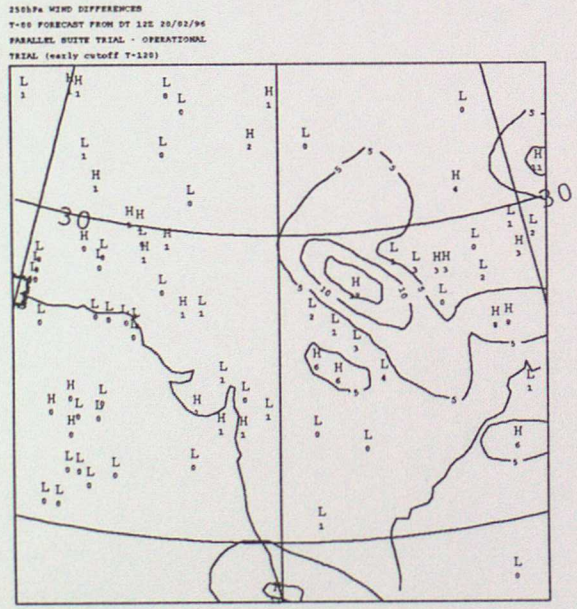
FIGURE 3.18



a

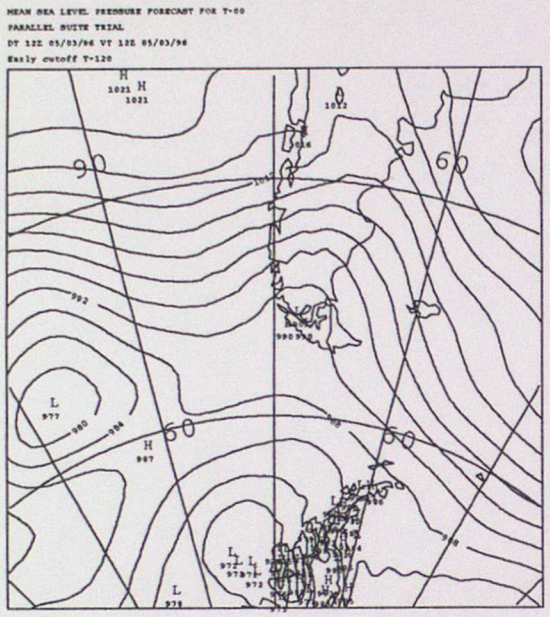


b



c

FIGURE 4.1



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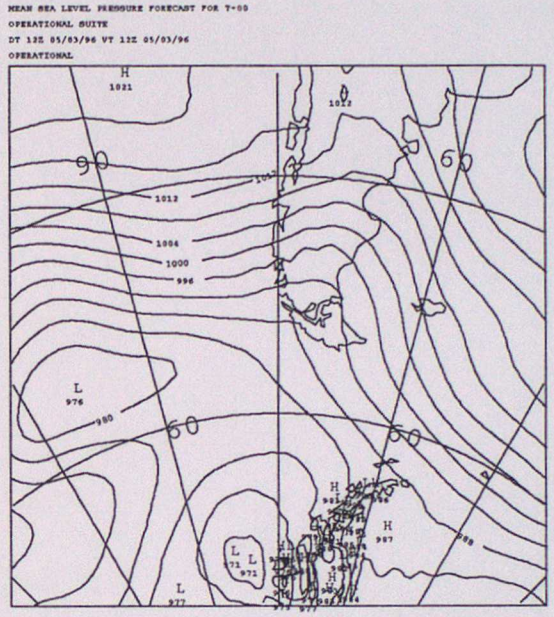
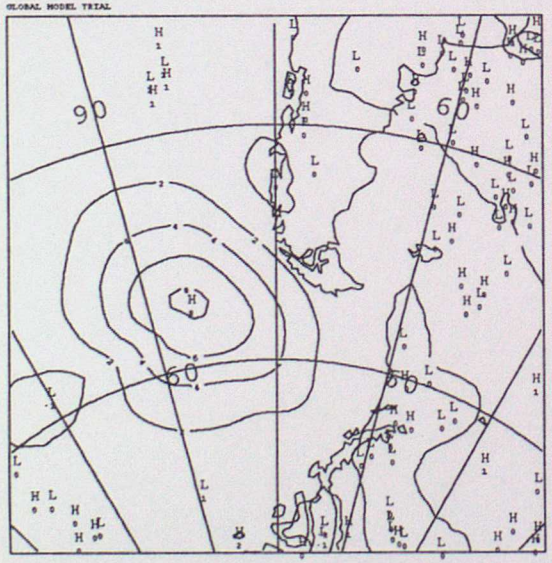


b



c

FIGURE 4.2

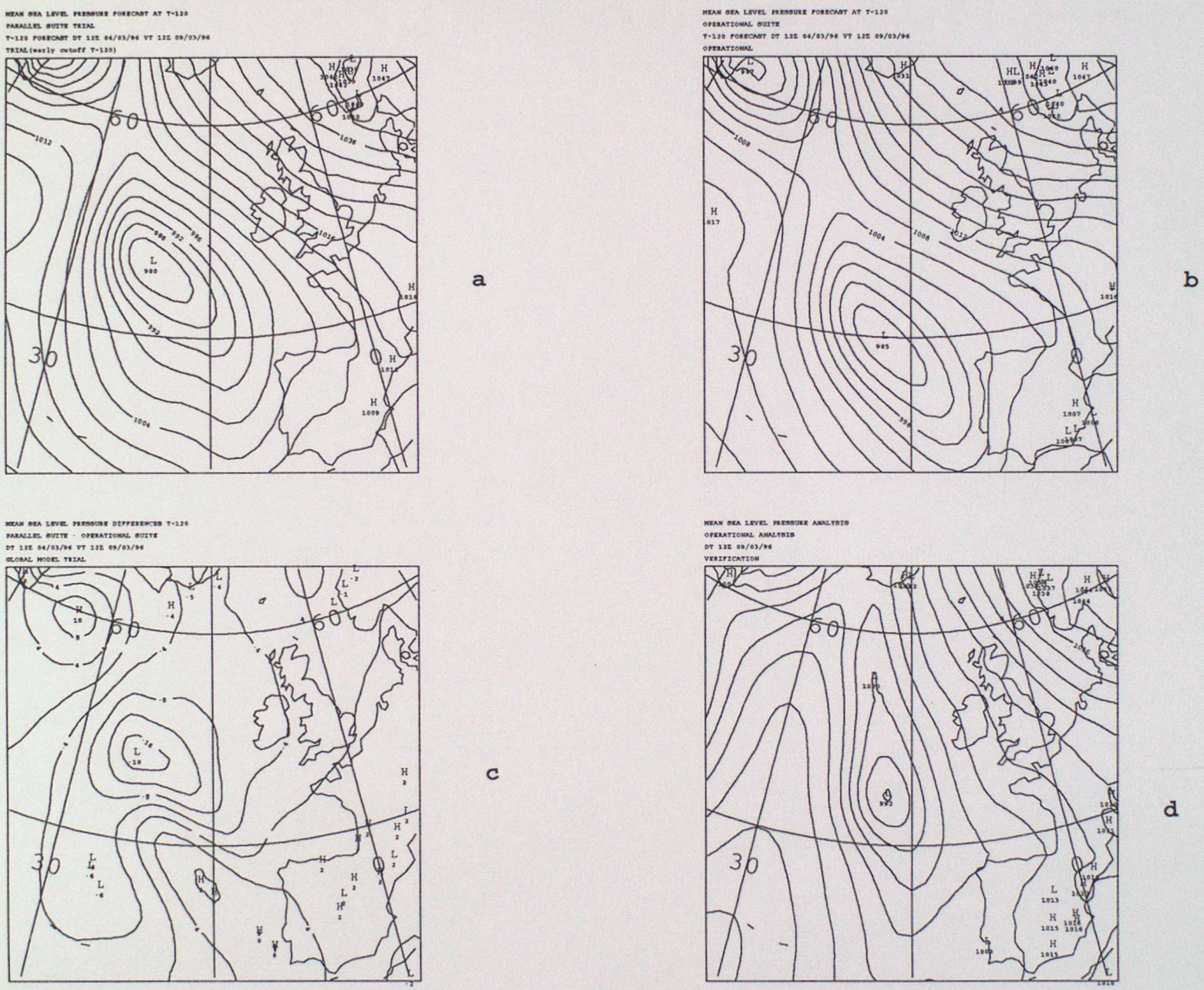
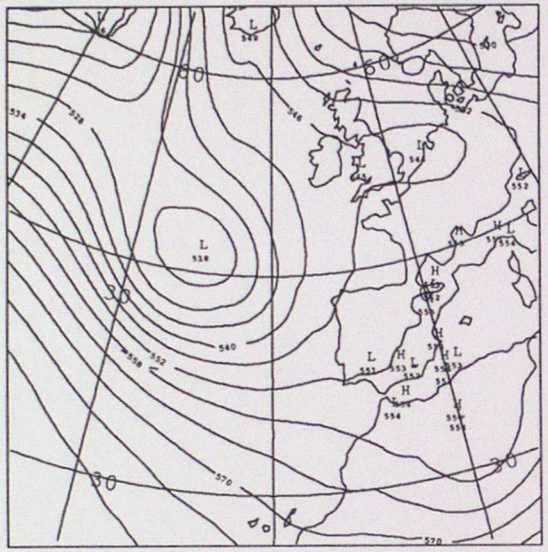

MEAN SEA LEVEL PRESSURE FORECAST AT T+120
PARALLEL SUITE TRIAL
T+120 FORECAST DT 12Z 04/03/96 VT 12Z 09/03/96
TRIAL(early cutoff T+120)
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+120
OPERATIONAL SUITE
T+120 FORECAST DT 12Z 04/03/96 VT 12Z 09/03/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T+120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 04/03/96 VT 12Z 09/03/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 09/03/96
VERIFICATION
d

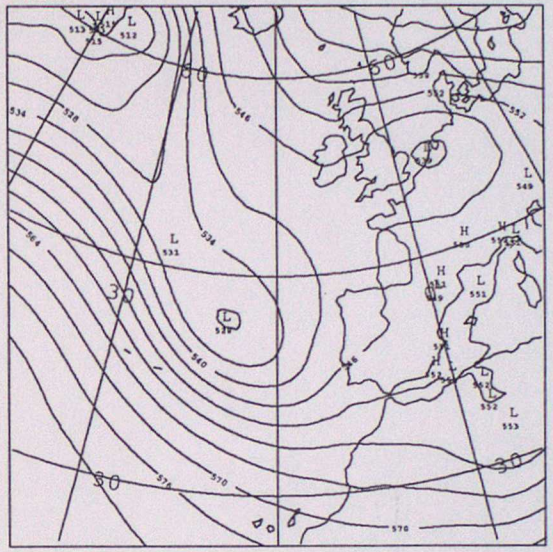
FIGURE 4.3

500hPa HEIGHT FORECAST AT T+120
PARALLEL SUITE TRIAL
DT 12Z 04/03/96 VT 12Z 09/03/96



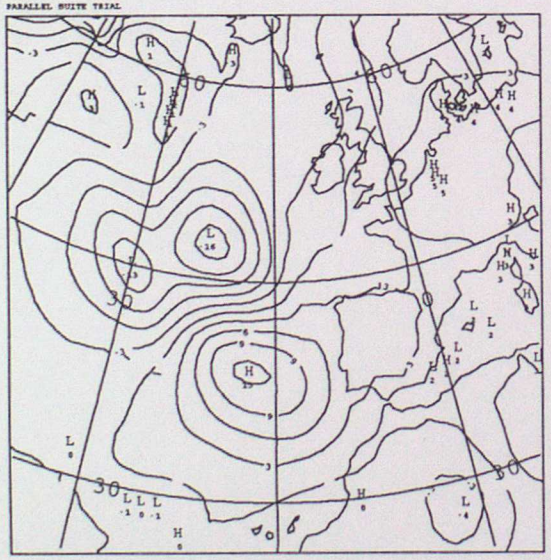
a

500hPa HEIGHT FORECAST AT T+120
OPERATIONAL SUITE
DT 12Z 04/03/96 VT 12Z 09/03/96
OPERATIONAL



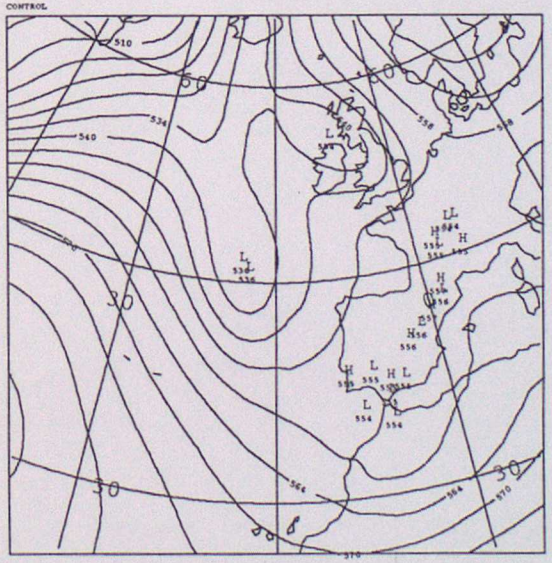
b

500hPa HEIGHT DIFFERENCES AT T+120
TRIAL - OPERATIONAL
DT 12Z 04/03/96 VT 12Z 09/03/96
PARALLEL SUITE TRIAL



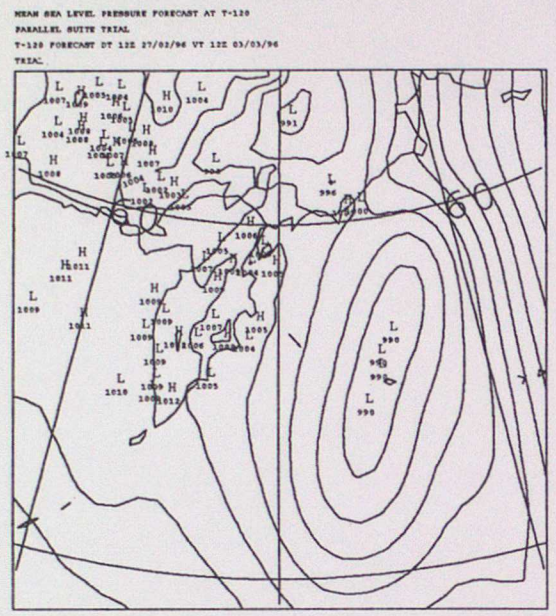
c

500hPa HEIGHT ANALYSIS
OPERATIONAL SUITE
DT 12Z 09/03/96
CONTROL

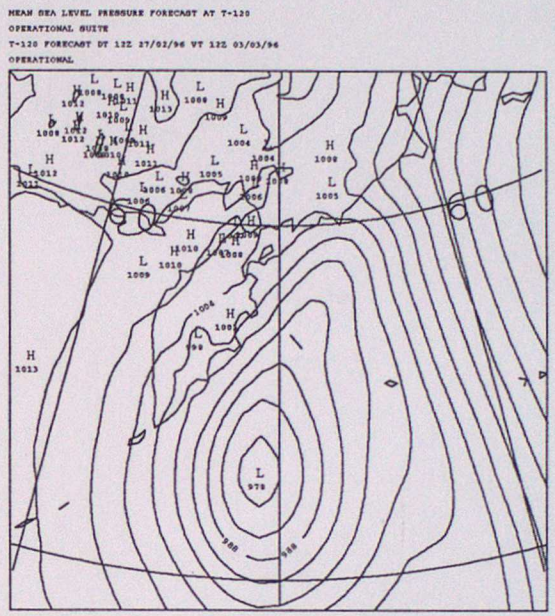


d

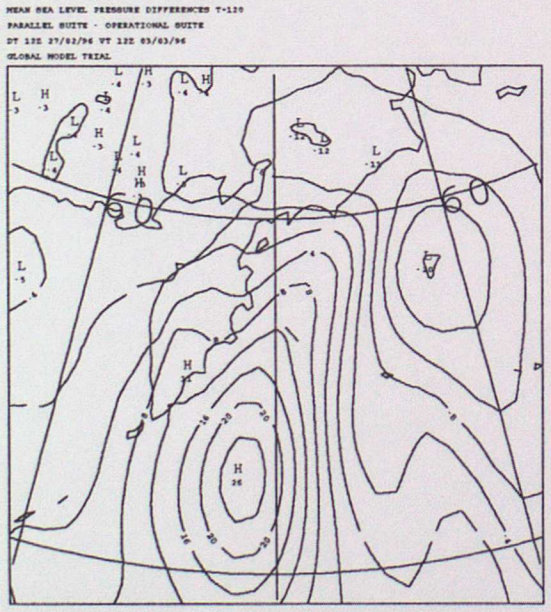
FIGURE 4.4



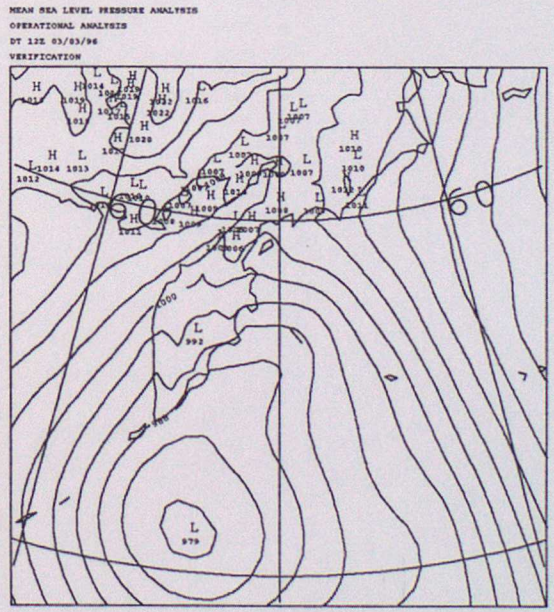
a



b



c



d

FIGURE 4.5

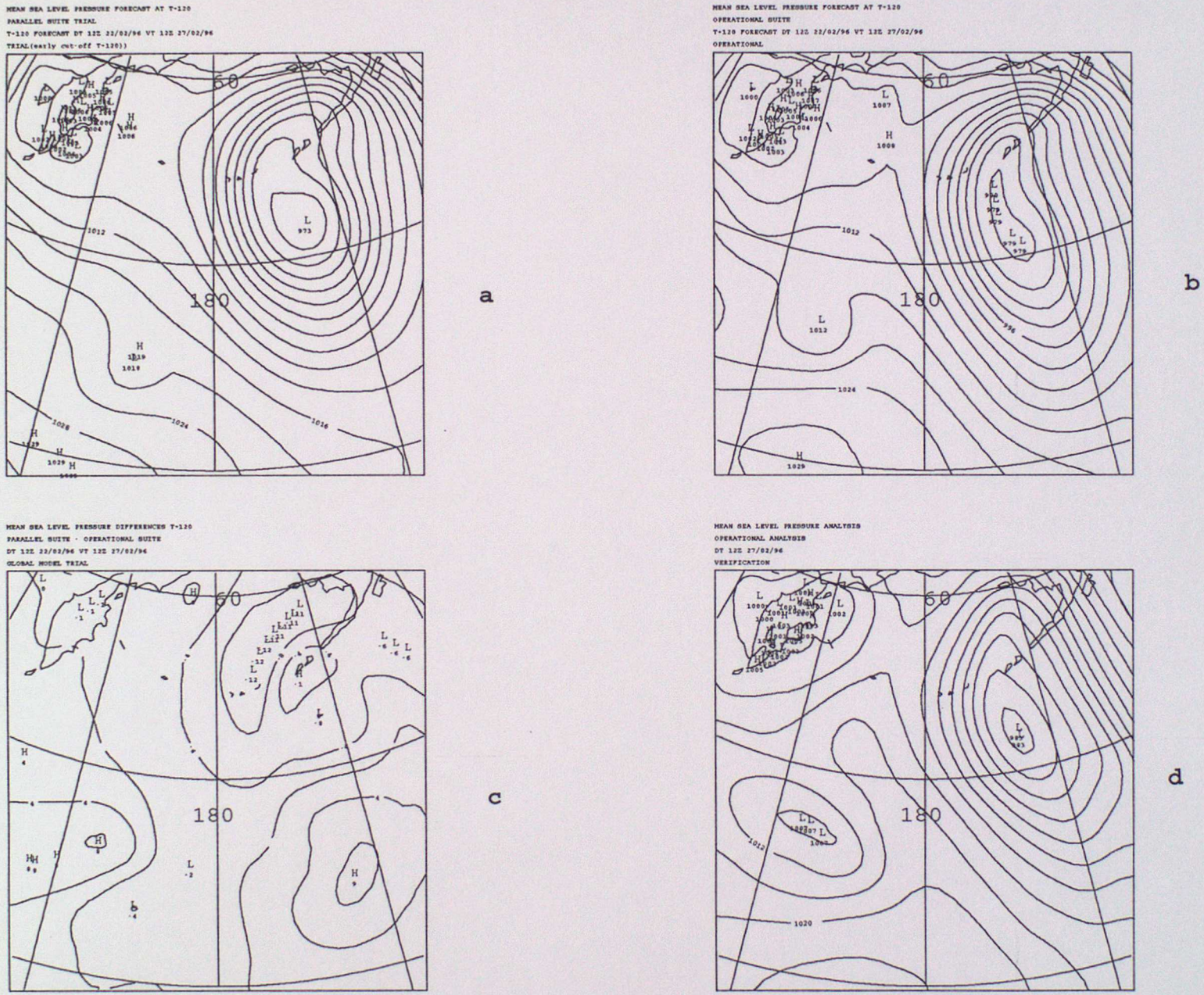
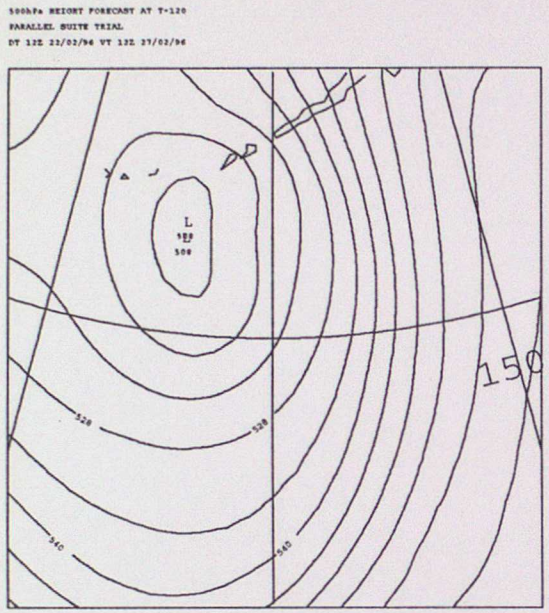
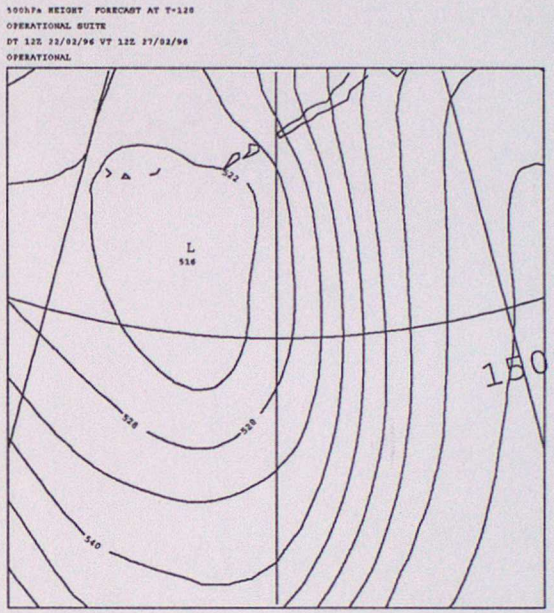

MEAN SEA LEVEL PRESSURE FORECAST AT T+120
PARALLEL SUITE TRIAL
T+120 FORECAST DT 12Z 22/02/96 VT 12Z 27/02/96
TRIAL(early cut-off T+120))
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+120
OPERATIONAL SUITE
T+120 FORECAST DT 12Z 22/02/96 VT 12Z 27/02/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T+120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 22/02/96 VT 12Z 27/02/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 27/02/96
VERIFICATION
d

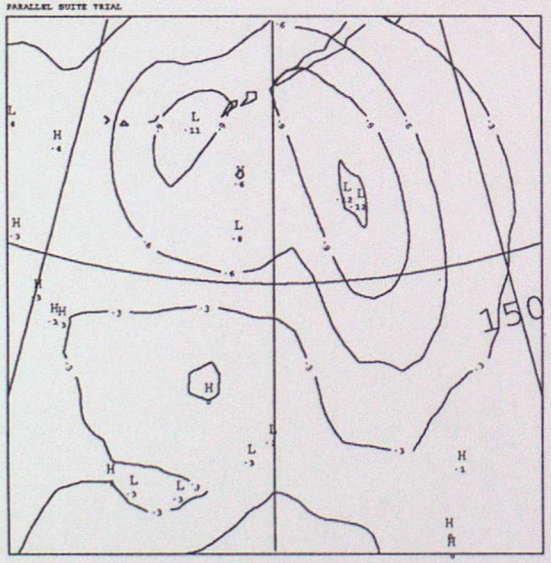
FIGURE 4.6



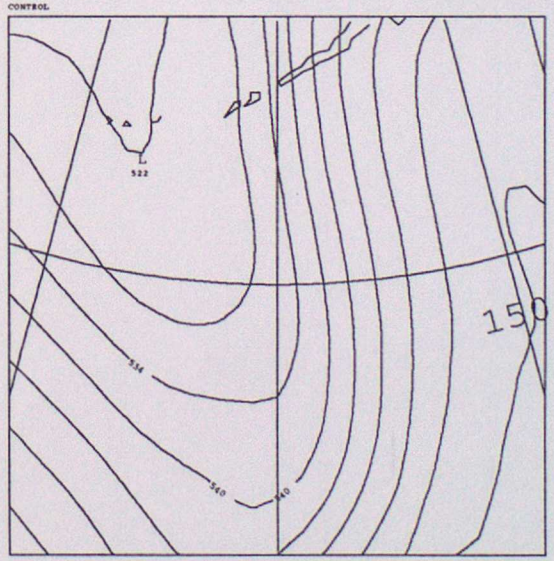
a



b



c



d

FIGURE 4.7

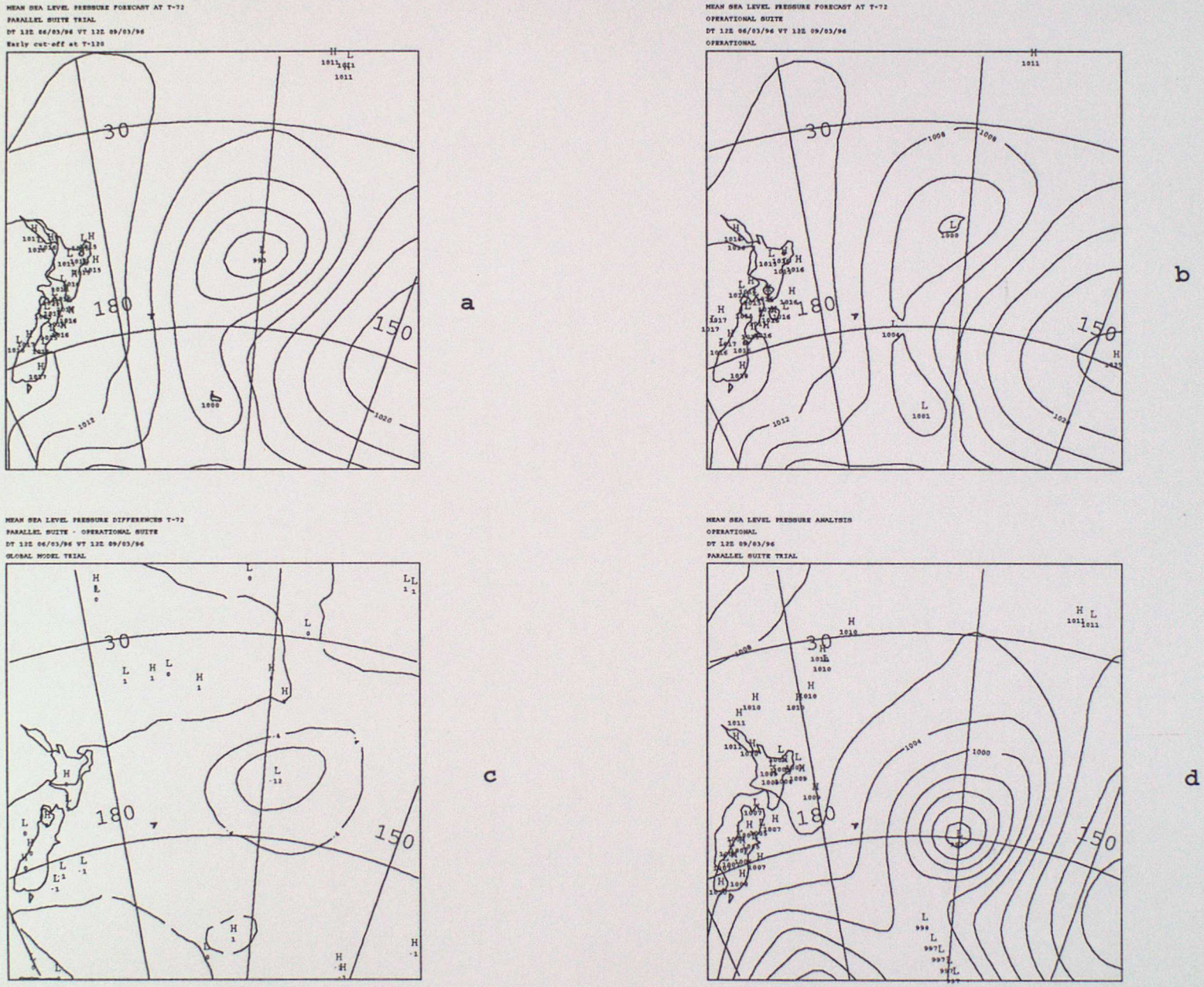
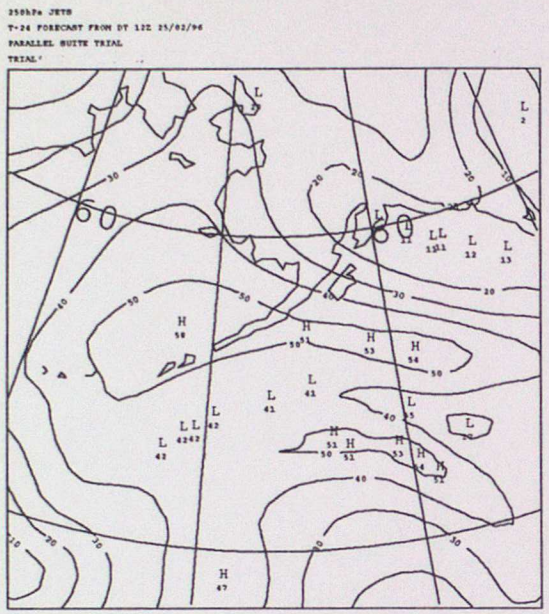
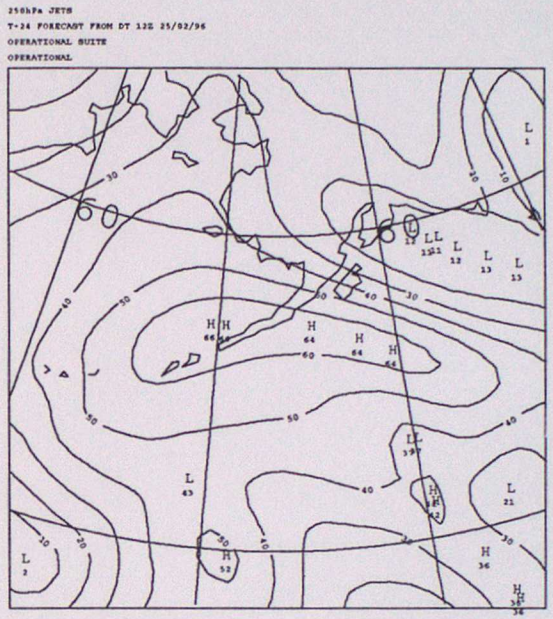

MEAN SEA LEVEL PRESSURE FORECAST AT T+72
PARALLEL SUITE TRIAL
DT 12Z 06/03/96 VT 12Z 09/03/96
Early cut-off at T+120
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+72
OPERATIONAL SUITE
DT 12Z 06/03/96 VT 12Z 09/03/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T+72
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 06/03/96 VT 12Z 09/03/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL
DT 12Z 09/03/96
PARALLEL SUITE TRIAL
d

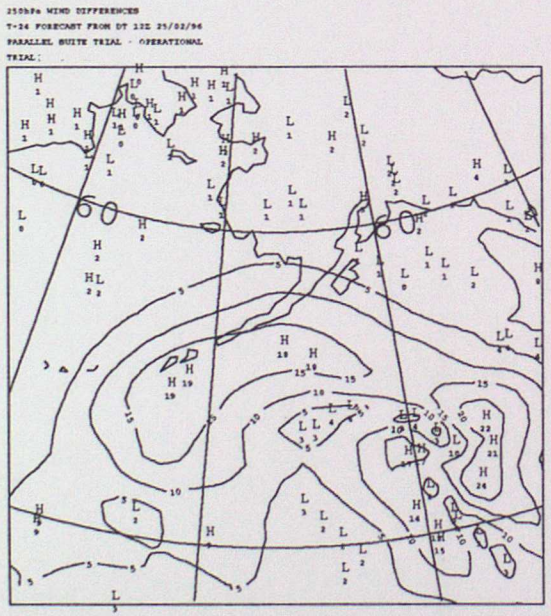
FIGURE 4.8



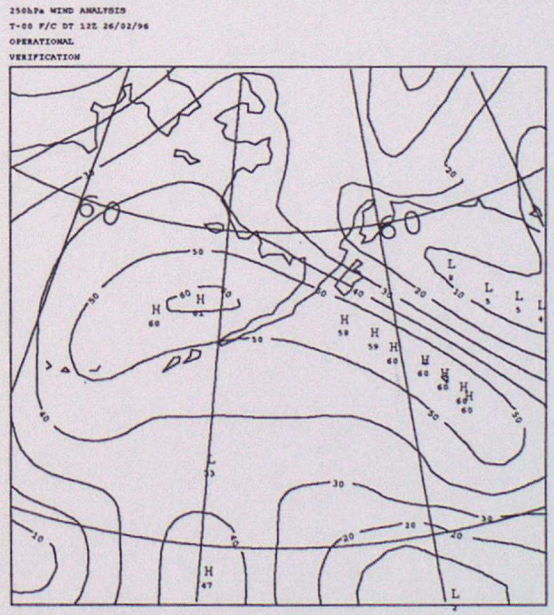
a



b

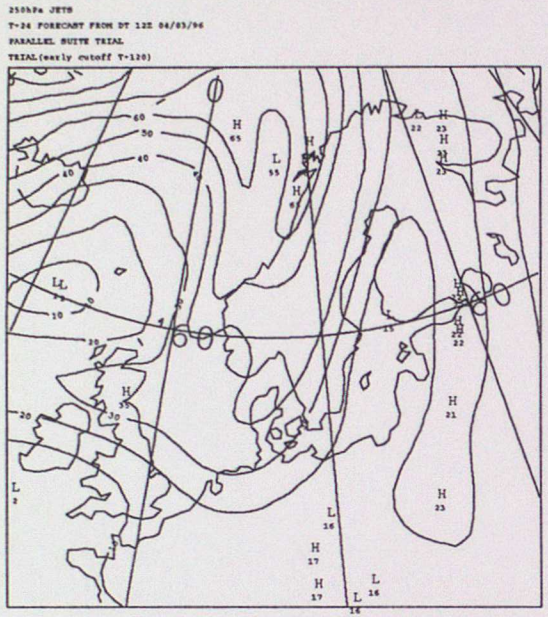


c

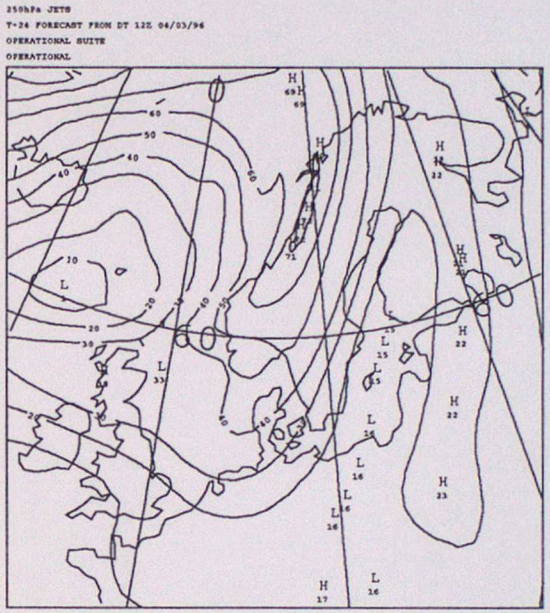


d

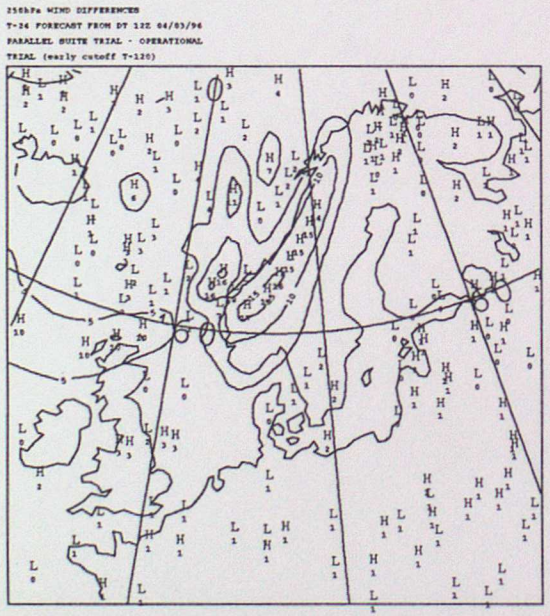
FIGURE 4.9



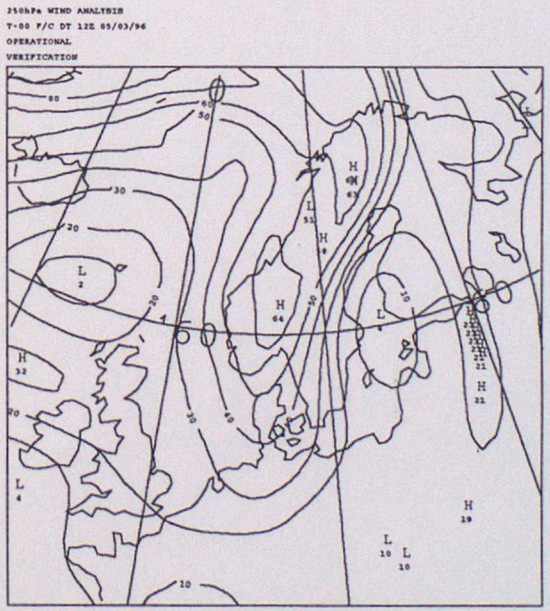
a



b

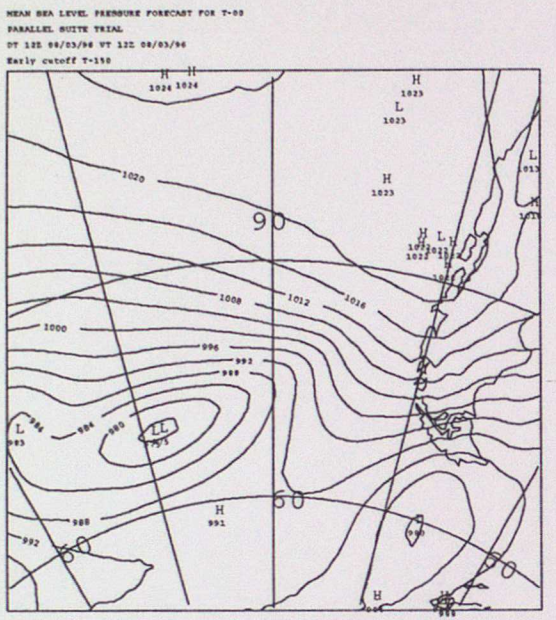


c

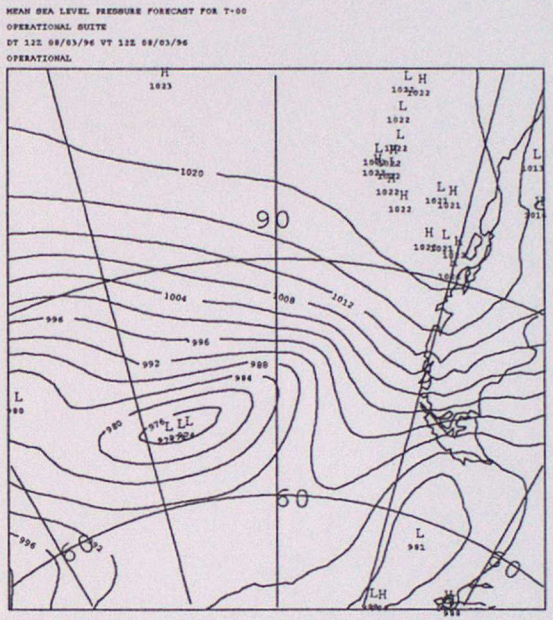


d

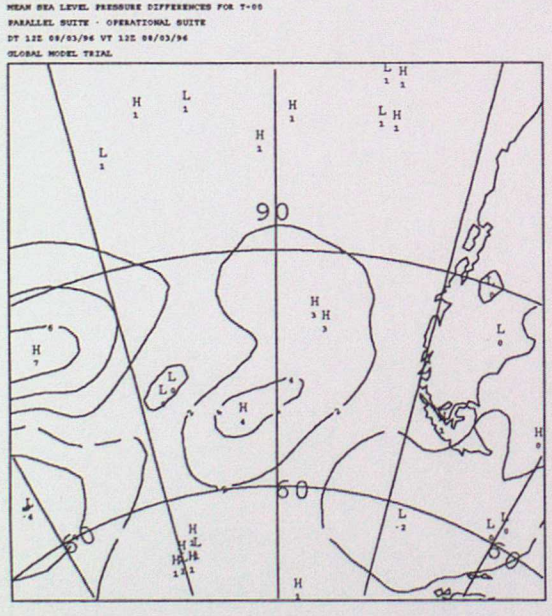
FIGURE 4.10



a

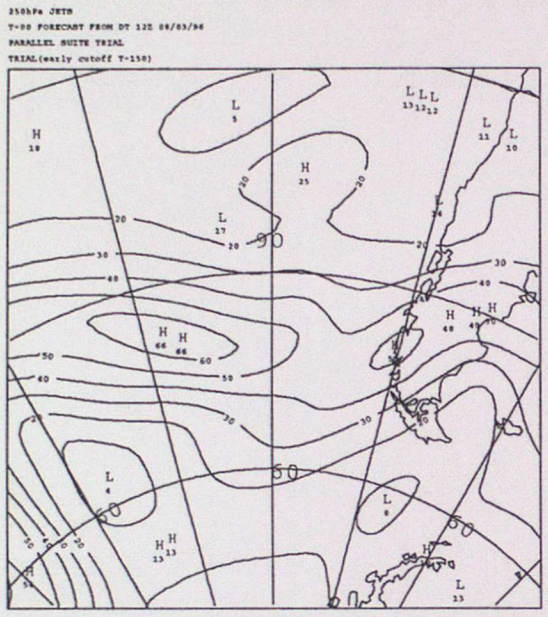


b

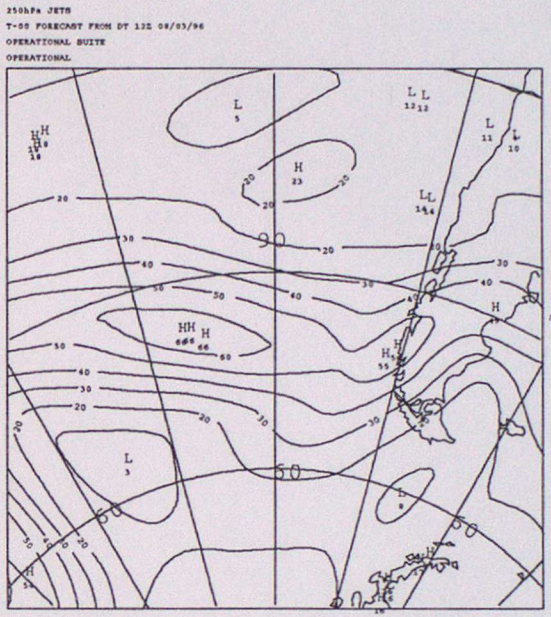


c

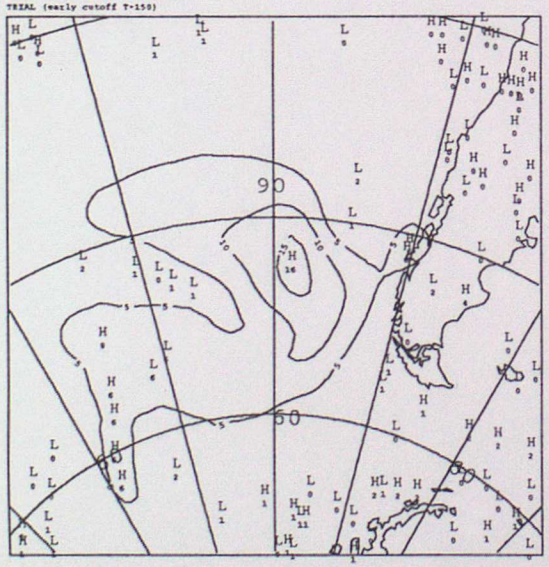
FIGURE 4.11



a



b



c

FIGURE 4.12

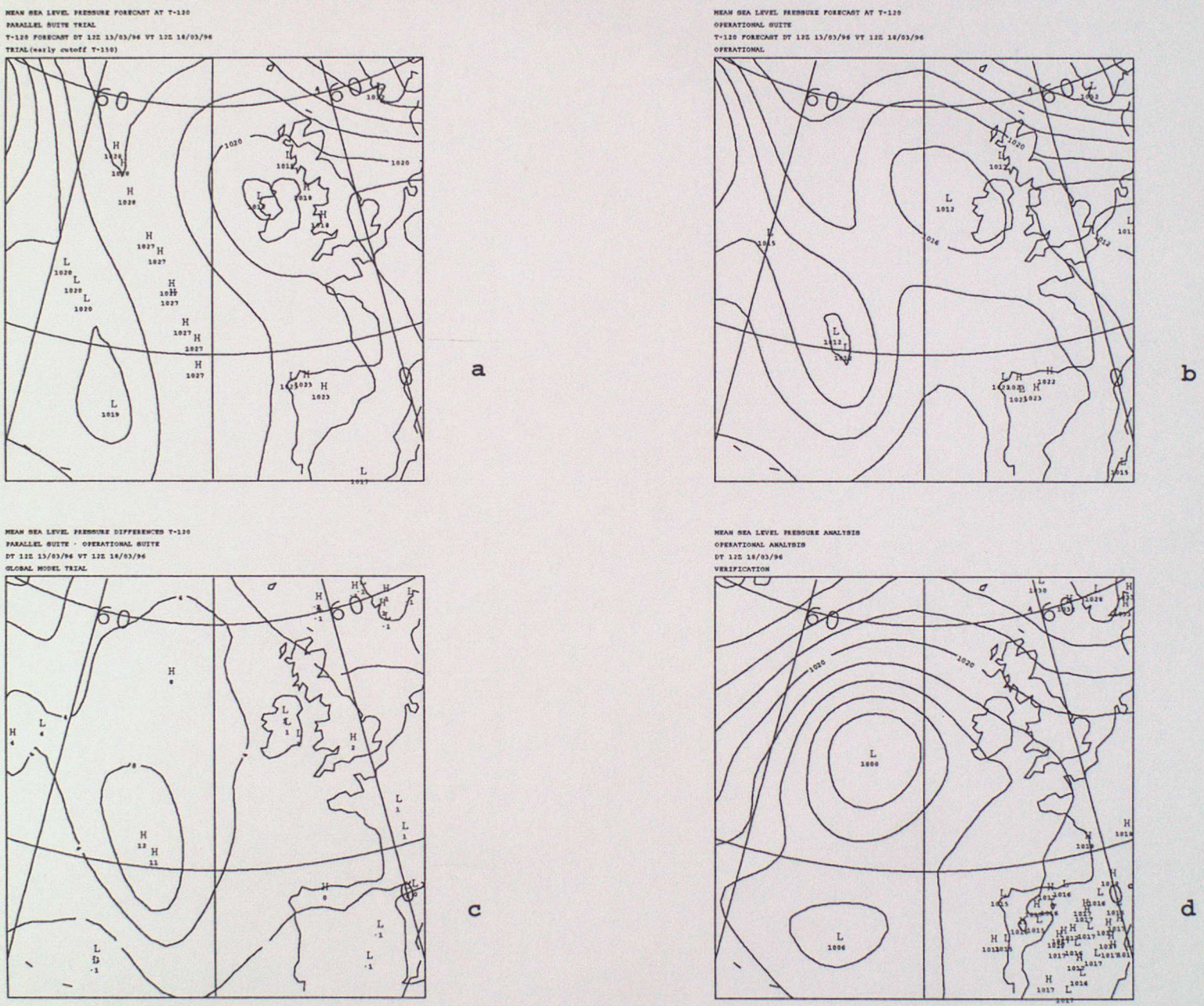

MEAN SEA LEVEL PRESSURE FORECAST AT T-120
PARALLEL SUITE TRIAL
T-120 FORECAST DT 12Z 13/03/96 VT 12Z 18/03/96
TRIAL(early cutoff T-150)
a
MEAN SEA LEVEL PRESSURE FORECAST AT T-120
OPERATIONAL SUITE
T-120 FORECAST DT 12Z 13/03/96 VT 12Z 18/03/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T-120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 13/03/96 VT 12Z 18/03/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 18/03/96
VERIFICATION
d

FIGURE 4.13

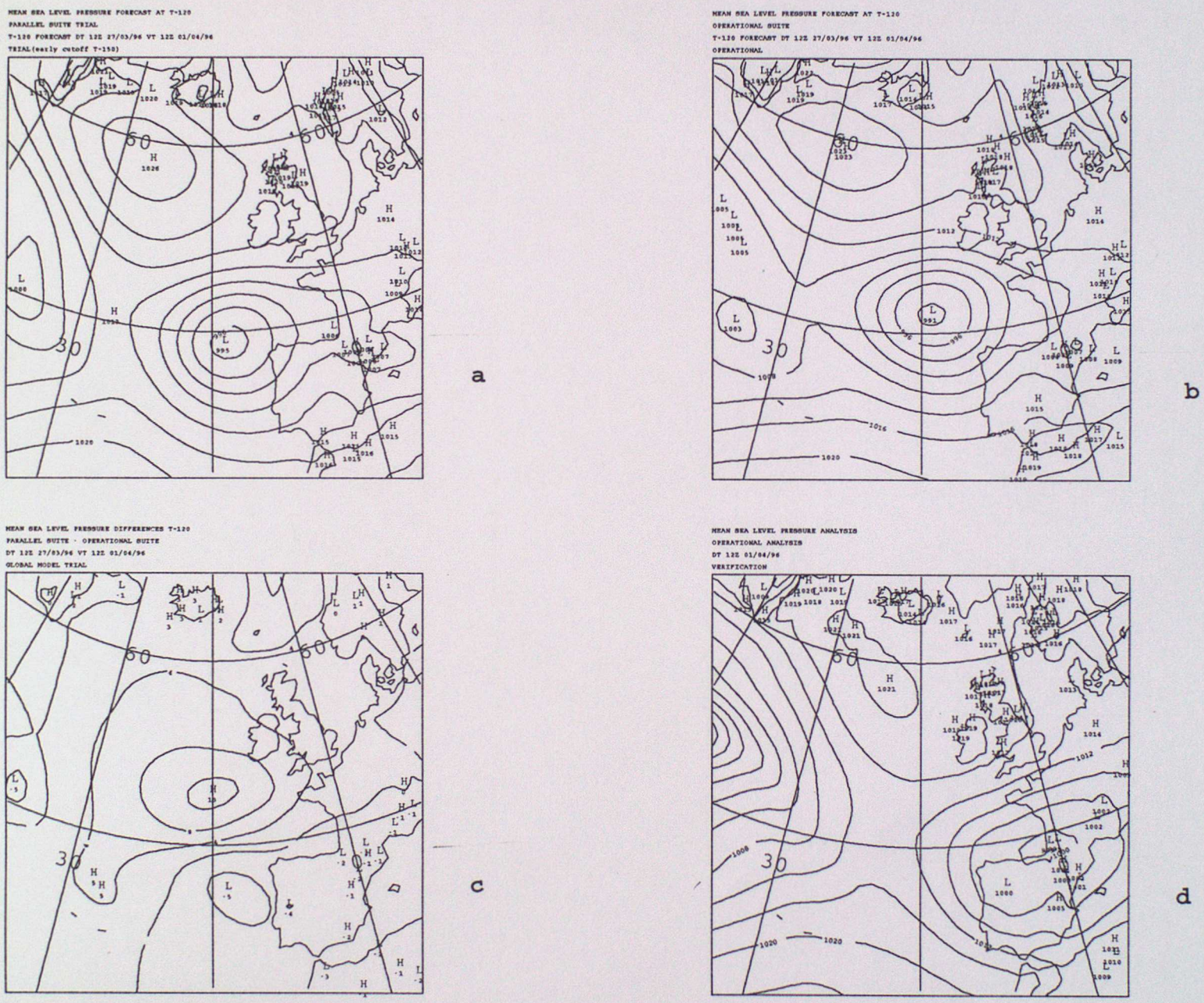

MEAN SEA LEVEL PRESSURE FORECAST AT T+120
PARALLEL SUITE TRIAL
T+120 FORECAST DT 12Z 27/03/96 VT 12Z 01/04/96
TRIAL(early cutoff T+150)
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+120
OPERATIONAL SUITE
T+120 FORECAST DT 12Z 27/03/96 VT 12Z 01/04/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T-120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 27/03/96 VT 12Z 01/04/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 01/04/96
VERIFICATION
d

FIGURE 4.14

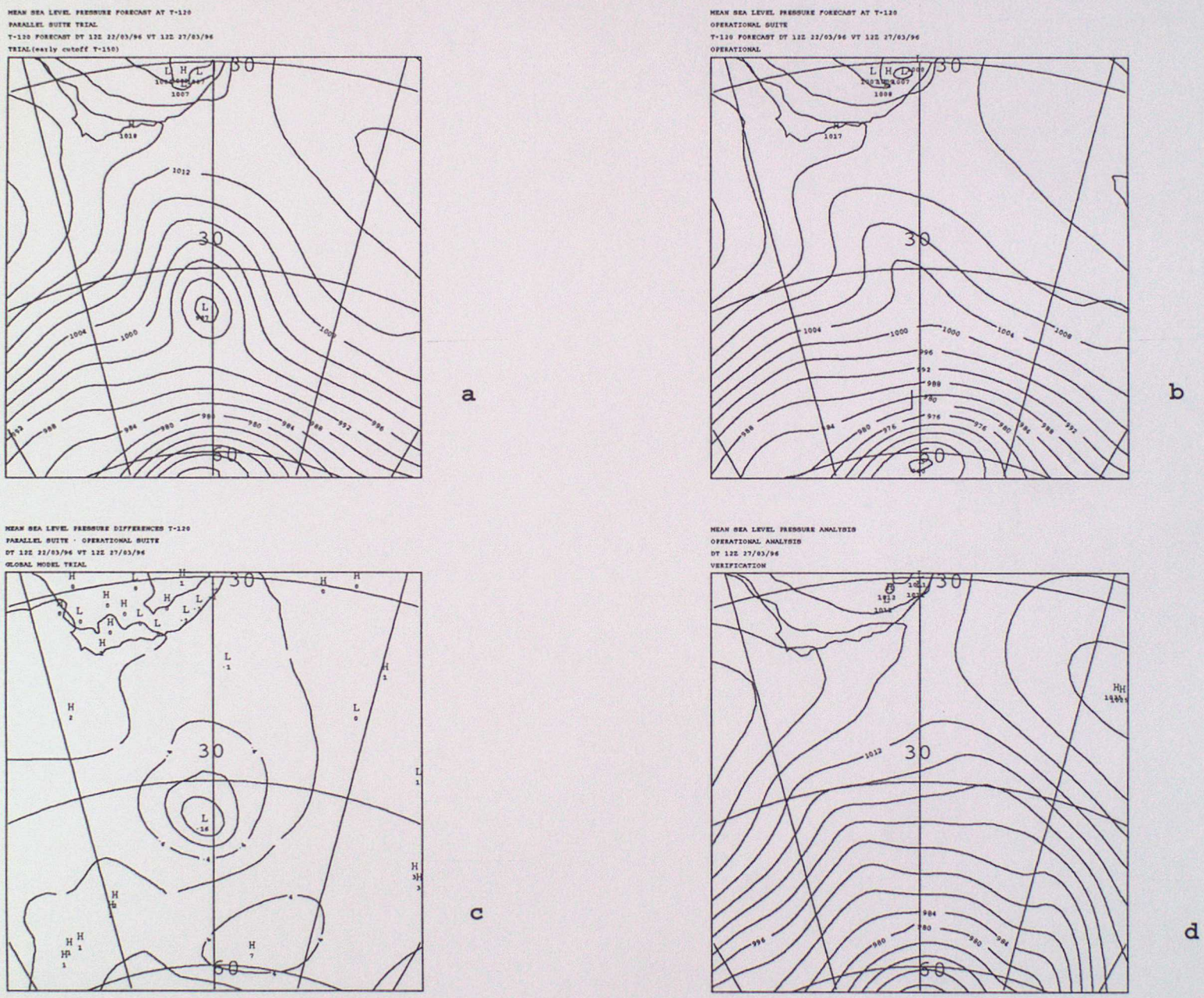

MEAN SEA LEVEL PRESSURE FORECAST AT T+120
PARALLEL SUITE TRIAL
T+120 FORECAST DT 12Z 22/03/96 VT 12Z 27/03/96
TRIAL(early cutoff T+150)
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+120
OPERATIONAL SUITE
T+120 FORECAST DT 12Z 22/03/96 VT 12Z 27/03/96
OPERATIONAL
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T-120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 22/03/96 VT 12Z 27/03/96
GLOBAL MODEL TRIAL
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 27/03/96
VERIFICATION
d

FIGURE 4.15

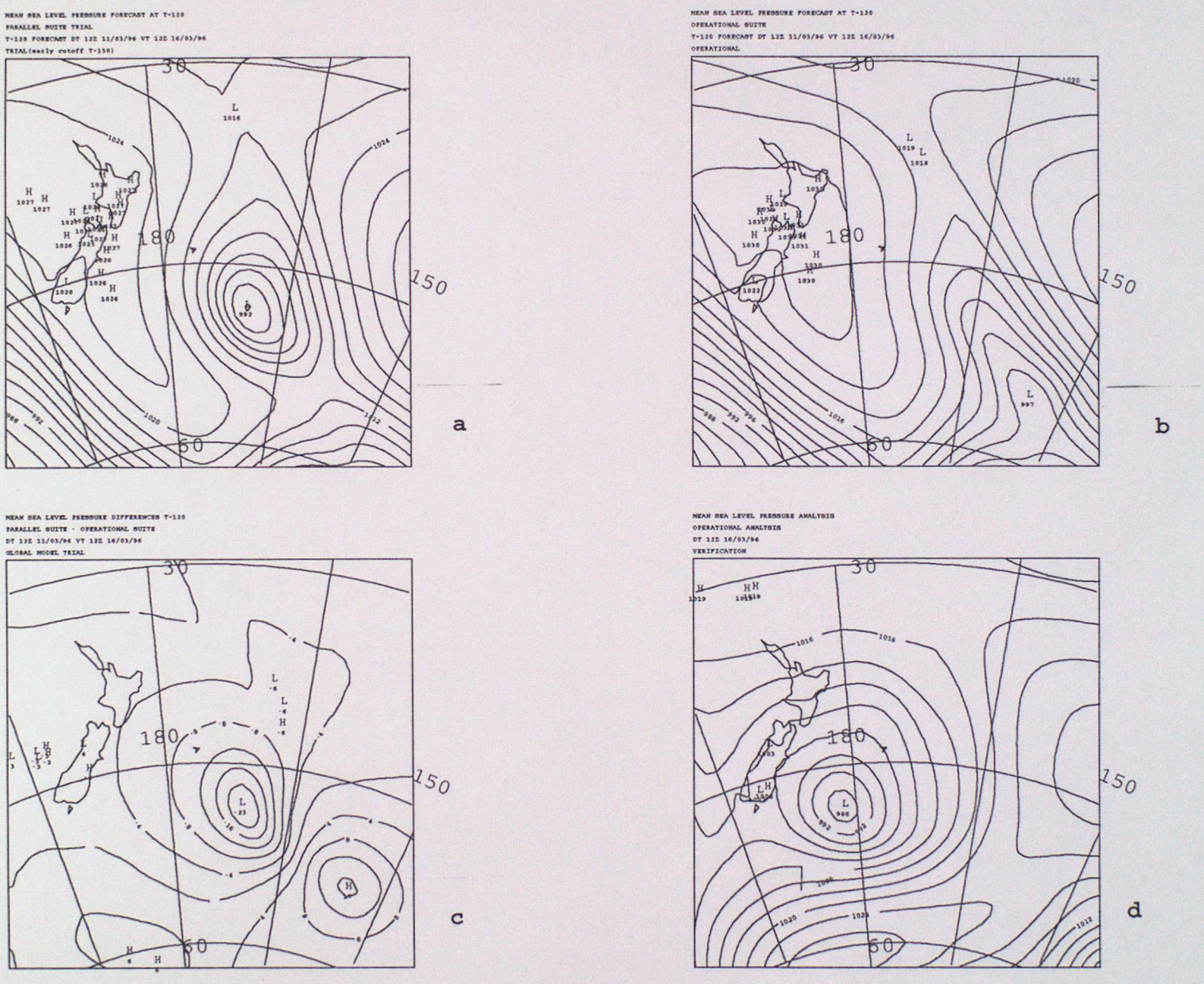
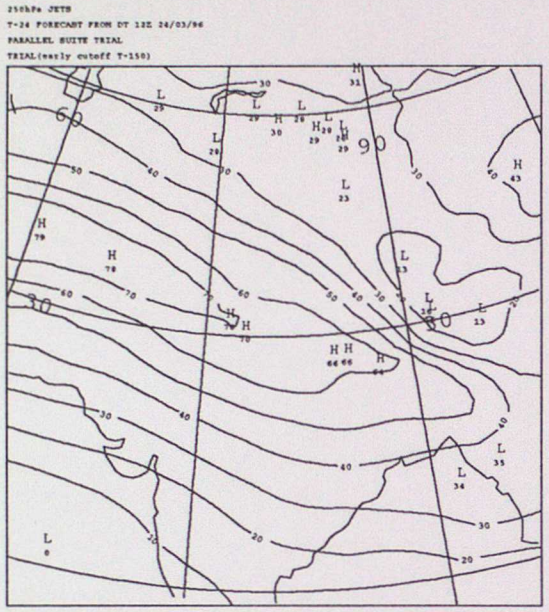
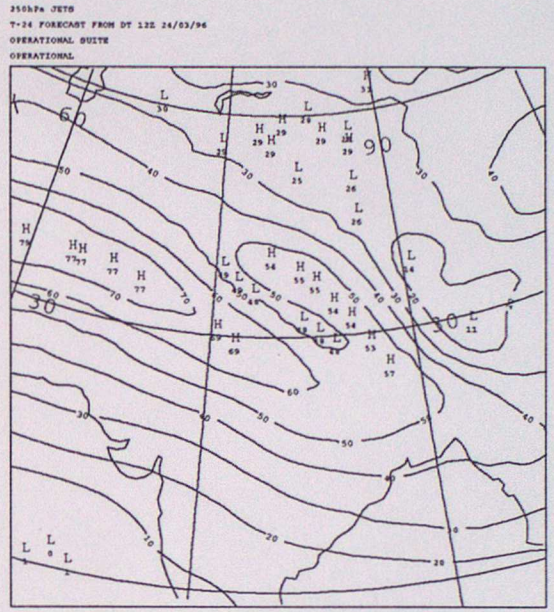

MEAN SEA LEVEL PRESSURE FORECAST AT T+120
PARALLEL SUITE TRIAL
T+120 FORECAST DT 12Z 11/03/96 VT 12Z 16/03/96
TRIAL(early cutoff T+150)
30
180
150
60
a
MEAN SEA LEVEL PRESSURE FORECAST AT T+120
OPERATIONAL SUITE
T+120 FORECAST DT 12Z 11/03/96 VT 12Z 16/03/96
OPERATIONAL
30
180
150
60
b
MEAN SEA LEVEL PRESSURE DIFFERENCES T+120
PARALLEL SUITE - OPERATIONAL SUITE
DT 12Z 11/03/96 VT 12Z 16/03/96
GLOBAL MODEL TRIAL
30
180
150
60
c
MEAN SEA LEVEL PRESSURE ANALYSIS
OPERATIONAL ANALYSIS
DT 12Z 16/03/96
VERIFICATION
30
180
150
60
d

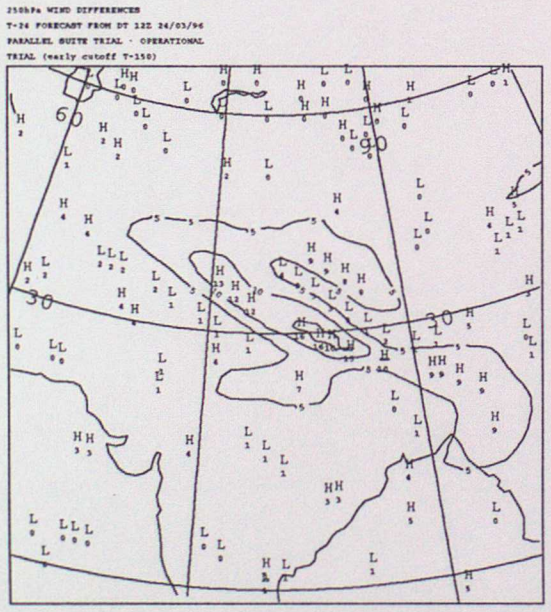
FIGURE 4.16



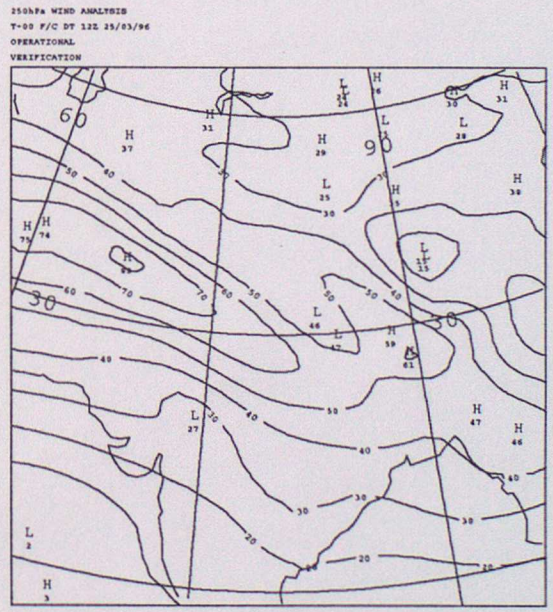
a



b

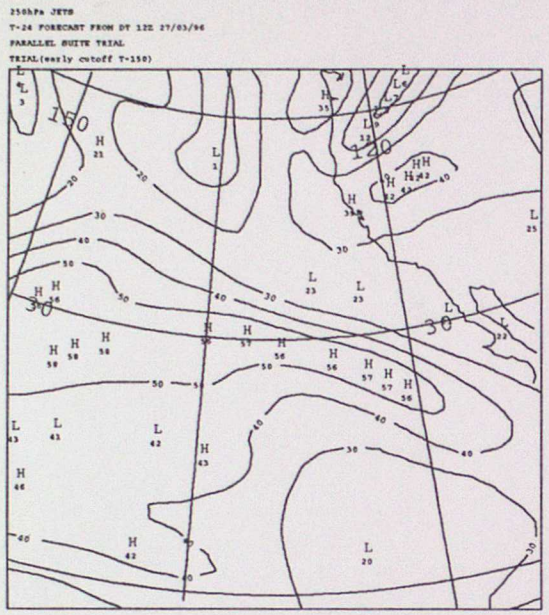


c

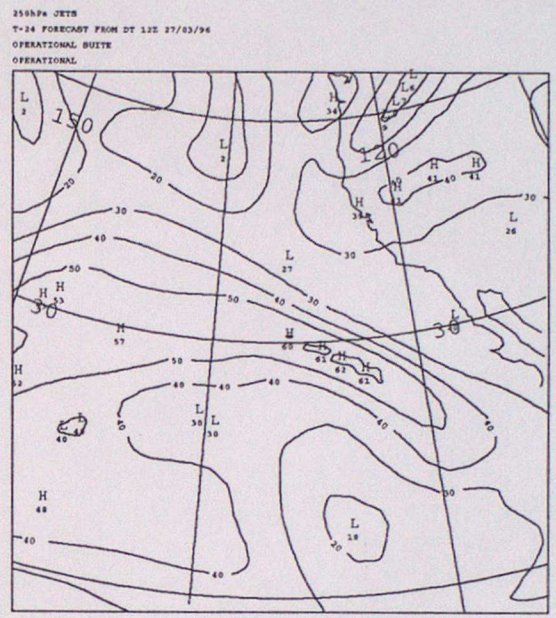


d

FIGURE 4.17



a



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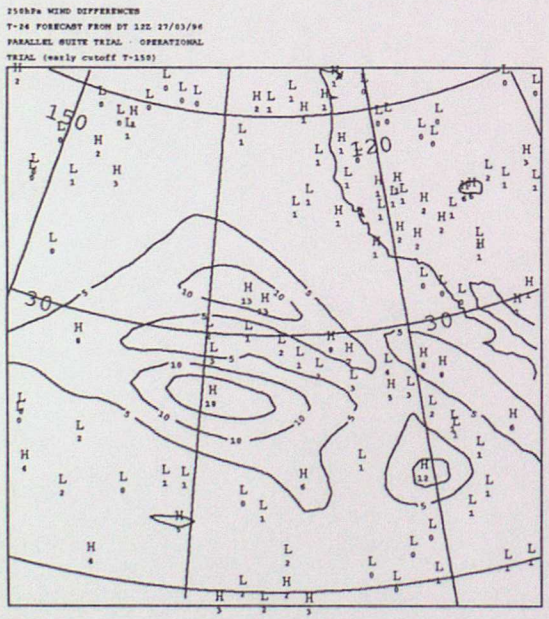

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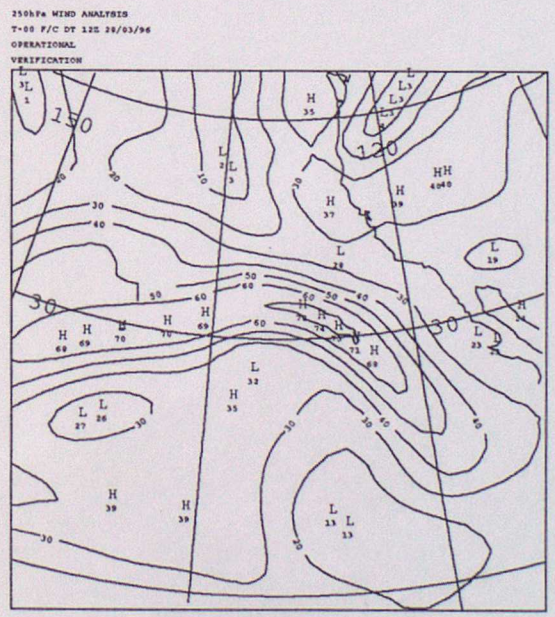

d

FIGURE 4.18